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10.—The genus *Ctenotus* (Lacertilia, Scincidae) in the Eastern Division of Western Australia.

by G. M. Storr*

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Abstract

The following 19 taxa are defined and keyed out: *pantherinus ocellifer* (Boulenger), *grandis* sp. nov., *helenae* sp. nov., *lesueurii* (Duméril & Bibron), *severus* sp. nov., *leonhardii* (Sternfeld), *uber* sp. nov., *mimetes* sp. nov., *dux* sp. nov., *ariadnae* sp. nov., *quattuordecimlineatus* (Sternfeld), *atlas* sp. nov., *impar* sp. nov., *piankai* sp. nov., *leae* (Boulenger), *calurus* sp. nov., *colletti nasutus* subsp. nov., *schomburgkii* (Peters) and *brooksi* (Loveridge).

Introduction

Scarcity of material has long delayed the revision of *Ctenotus*, largest and least known of Australian reptile genera. Recently it has become not only possible but urgent to revise the species inhabiting the Eastern Division of Western Australia.

In late 1966 American herpetologist Dr E. R. Pianka set up several study areas in the southern half of the Division. Here he worked on various aspects of the ecology of desert lizards, in the course of which some hundreds of specimens of *Ctenotus* were collected. In order to provide Dr Pianka with names, old and new, I examined the greater part of his beautifully preserved

series, all the Eastern Division material in the Western Australian Museum, and the type specimens of most of the named taxa occurring in the Division. In addition some hundreds of specimens from neighbouring regions were examined, but unless indicated to the contrary data from these specimens were not used in descriptions.

Besides coloration the following measurements, counts and observations were made on all specimens: snout-vent length in mm (abbreviated to SVL); length of tail, foreleg and hindleg (all expressed as % SVL); nature of nasal and prefrontal contacts; number of supraoculars, supraciliaries and scales along lower edge of upper eyelid (the last are referred to simply as "palpebrals"); ratio width to height of second loreal; number of upper labials; number and shape of ear lobules; number of enlarged dorsal scales on each side of neck (referred to simply as "nuchals"); number of longitudinal scale-rows round middle of body; number and nature of lamellae under fourth toe (here the term "calli" is used for thickenings too low and wide to be called keels). In the descriptions only ranges are given for quantitative characters; the means are brought together in Table 1.

Table 1

Number of specimens (number with original tail in brackets) and mean value of following characters: SVL (snout-vent length in mm); length of appendages (as % SVL); ratio width to height of second loreal; and number of midbody scale-rows, lamellae under fourth toe, supraciliaries, palpebrals, upper labials, ear lobules and nuchals. Data solely from material listed in accounts of species.

	N	SVL	Tail	Fore-leg	Hind-leg	Loreal	Scale rows	Lamel-lae	Supra-cilia-ries	Pal-pebrals	Lab-ials	Ear lob-ules	Nuchals
<i>ocellifer</i>	62 (21)	72	154	25.0	37.8	1.02	34.6	23.3	6.9	11.2	8.0	4.6	3.0
<i>grandis</i>	63 (20)	76	174	24.0	37.1	1.04	32.3	22.2	7.6	11.0	8.0	5.7	2.9
<i>helenae</i>	72 (30)	80	187	21.6	35.7	1.39	28.8	21.2	7.0	10.6	8.1	4.5	2.7
<i>lesueurii</i>	21 (3)	76	233	23.2	40.0	1.31	29.1	21.2	7.3	10.8	8.0	5.2	2.7
<i>severus</i>	37 (14)	69	213	24.0	42.0	1.35	29.8	20.8	7.2	10.5	8.2	4.9	2.9
<i>leonhardii</i>	138 (74)	63	208	25.0	48.0	1.39	28.5	25.1	7.3	10.4	8.0	4.4	3.8
<i>uber</i>	14 (8)	60	222	26.3	50.4	1.36	30.8	25.8	7.0	11.3	8.1	4.2	3.6
<i>mimetes</i>	10 (5)	65	236	25.2	50.9	1.33	27.8	26.2	6.9	12.1	8.1	4.0	3.3
<i>dux</i>	54 (38)	42	198	29.3	49.5	1.48	30.0	26.7	6.8	11.0	8.1	4.4	3.0
<i>ariadnae</i>	7 (4)	49	174	25.4	41.1	1.40	31.1	22.6	6.6	9.8	8.0	5.4	2.6
<i>quattuordecimlineatus</i>	88 (33)	55	207	26.1	44.1	1.43	28.7	24.3	7.0	10.6	8.0	4.1	2.6
<i>atlas</i>	31 (10)	57	206	25.6	44.2	1.42	29.9	23.3	6.8	11.5	8.0	3.8	2.6
<i>impar</i>	22 (7)	55	188	25.2	41.7	1.23	27.7	21.8	6.9	10.2	7.0	3.7	3.0
<i>piankai</i>	11 (5)	38	219	29.4	45.7	1.23	24.9	22.4	6.5	9.9	8.0	3.5	3.1
<i>leae</i>	20 (12)	52	252	28.1	53.9	1.26	23.1	26.5	6.8	10.6	8.0	3.3	3.4
<i>calurus</i>	34 (21)	38	203	26.2	49.3	1.87	25.5	21.8	6.8	9.7	7.0	3.6	3.5
<i>nasutus</i>	6 (5)	38	217	26.4	45.4	1.75	24.0	24.2	6.0	9.7	7.7	2.1	3.7
<i>schomburgkii</i>	77 (45)	40	171	26.4	48.7	1.56	26.8	21.8	6.8	9.3	7.1	3.1	3.6
<i>brooksi</i>	56 (36)	38	184	27.1	50.4	1.85	25.4	24.1	6.7	9.6	7.4	3.3	2.3

Material in the Western Australian Museum is prefixed with R; in Dr Pianka's collection with ERP (usually his field-number is not cited but only number of specimens from a locality separated by a comma from the prefix); in the collections of the Joint British Services Expedition to Central Australia by JSE (kindly lent by Lt Cdr A. Y. Norris); and in the Museum of Comparative Zoology by MCZ (kindly lent by Dr. E. Williams). For the loan of the types of *leae* and *inornatus* I am indebted to Mr E. N. Arnold (British Museum); for *pantherinus* and *schomburgkii* to Dr G. Peters (Berlin Museum); *colletti*, Dr P. Pethon (Oslo Museum); *taeniatus*, Mr F. J. Mitchell (South Australian Museum); *schevilli*, Mr J. T. Woods (Queensland Museum); and *brooksi*, Dr E. Williams. I am grateful to Mrs Ariadna Neumann (Librarian, Western Australian Museum) for translating papers by Peters, Fischer and Sternfeld, and to Dr E. R. Pianka for guidance and criticism.

Genus *Ctenotus*

Ctenotus Storr, 1964, W. Aust. Nat. 9: 84.

Type-species *Lacerta taeniolata* Shaw.

Diagnosis. Active, diurnal, terrestrial, small to moderately large, slender to moderately stout, smooth-scaled skinks with well-developed pentadactyl limbs; long, slender, fragile tail; no supranasals; frontoparietals and interparietal free; lower eyelid movable, without a transparent disc; 2 loreals; 3 temporals, upper secondary much the largest, primary and lower secondary subequal and usually a little smaller than last two labials; ear aperture moderately large with sunken tympanum. Distinguishable from *Egernia* and *Omolepida* by contact of parietals behind interparietal, and from *Sphenomorphus* by presence of ear lobules and by colour pattern consisting mainly of longitudinal lines, stripes and rows of spots.

Distribution. Continental Australia and southern New Guinea.

Remarks. As an aid in diagnosis, I have tentatively placed the 19 species of the Eastern Division in 6 species-groups named after the earliest known species in each, viz. *pantherinus*, *grandis*, *lesueurii*, *taeniolatus*, *colletti* and *schomburgkii*. Whether these species-groups constitute natural assemblages will remain unknown until a greater part of the genus is studied and additional characters are considered. Meanwhile it seems best not to define them formally but to let students infer their superficial characters from the first five couplets in the following key.

Key

1. Dorsal and lateral pattern entirely ocellate; nasal strongly grooved; subdigital lamellae sharply keeled *pantherinus ocellifer*
- Dorsal pattern not ocellate; lateral pattern usually not ocellate (ocelli may be present on side of body and tail in *grandis*); nasal weakly or not grooved 2
2. Subdigital lamellae smooth, callose or obtusely keeled; snout short to moderately long, not low or narrow; body and appendages slender to stout; size small to very large 3
- Subdigital lamellae with a fine, sharp keel usually ending in a mucron or short spine; head low;

- snout long, low and narrow; body and appendages slender; size minute to small (SVL up to 62) 4
3. Dorsal pattern striped or plain; lateral pattern either plain, spotted or combining spots with stripes; subdigital lamellae smooth, callose or obtusely keeled; body and appendages slender to stout; size medium to very large; nasals usually separated (except in *leonhardii* and *grandis*) 5
- Dorsal and lateral pattern consisting entirely of alternating dark and pale stripes (except in *piankai*, whose dark upper lateral stripe may enclose a line of white dots); subdigital lamellae narrowly callose or obtusely keeled; body and appendages slender; size small (SVL up to 70); nasals usually in contact (except in *impar*)—*taeniolatus* group 12
4. Dorsal and lateral pattern consisting entirely of clearcut alternating dark and pale stripes; nasals usually in contact; size minute to small—*colletti* group 17
- Dorsal pattern striped, variegated or indistinct; lateral pattern spotted, blotched or vertically barred; nasals usually separated; size minute (SVL up to 50)—*schomburgkii* group 19
5. Back indistinctly or boldly striped; sides greyish with white centres of scales tending to form vertical bars; second loreal usually high and apically angular; nasals often in contact—*grandis* group 6
- Sides with or without stripes but pattern clearcut (except in *helenae*) with pale markings (when present) longitudinally aligned; second loreal usually oblong and lower than wide; nasals seldom in contact (except in *leonhardii*)—*lesueurii* group 7
6. Back reddish, striped with dark brown (vertebral stripe well developed; others may be discontinuous or barely discernible); tail short and thick, basally constricted and with buffy dark-edged vertical bars on side *grandis* (adult)
- Back with alternating black and pale green stripes; tail slender *grandis* (juv)
7. Back dark greenish brown, with or without black vertebral stripe but seldom with black laterodorsal stripe; lateral pattern obscure, with little or no indication of pale dorsolateral and midlateral stripes; sides of body and tail (and often under tail) dotted with black *helenae*
- Back usually reddish brown (never greenish); white dorsolateral line conspicuous and margined above by blackish laterodorsal stripe; dark upper lateral stripe enclosing one or two series of pale dots, spots or blotches 8
8. Back reddish brown, entirely without pattern between narrow black laterodorsal stripes; conspicuous white midlateral stripe from lores to groin, not much wider than white dorsolateral line; dark upper lateral stripe almost completely broken by pale squarish blotches *mimetes*
- Some indication of dark vertebral stripe (if only a median line on neck); blackish laterodorsal stripe much wider than white dorsolateral line (except occasionally in *severus* and *uber*); white midlateral stripe either absent, poorly developed (e.g. not extending forward to level of foreleg) or well developed (in which case it is much wider than dorsolateral

- line); dark upper lateral stripe enclosing pale dots or small spots (large only in *lesueurii*) 9
9. Dark vertebral stripe well developed and narrowly edged with white or pale brown; dark upper lateral stripe in contact with white dorsolateral line 10
- Dark vertebral stripe reduced to a line, i.e. sutures between paravertebral scales (occasionally wider in *severus*) 11
10. Dark upper lateral stripe with one or 2 series of pale dots; toes moderately compressed, with more than 20 lamellae under fourth, each with a narrow brown callus or obtuse keel; nasals usually in contact; prefrontals usually separated; nuchals usually more than 3; SVL up to 78 *leonhardii*
- Dark upper lateral stripe with a series of pale spots or blotches; toes not compressed, with fewer than 24 lamellae under fourth, mostly with a low, very wide callus (higher proximally); nasals usually separated; prefrontals usually in contact; nuchals rarely more than 3; SVL up to 97 *lesueurii*
11. Dark laterodorsal stripe usually enclosing a series of pale spots; dark upper lateral stripe in contact with white dorsolateral line; little or no indication of white midlateral stripe; toes moderately compressed, with more than 20 lamellae under fourth, each with a narrow brown callus or obtuse keel; SVL up to 70 *uber*
- Dark laterodorsal stripe not enclosing a series of pale spots; dark upper lateral stripe narrowly separated from white dorsolateral line; white midlateral stripe discernible; toes not compressed, with fewer than 24 lamellae under fourth, mostly with a wide flat callus (higher proximally); SVL up to 91 *severus*
12. Vertebral stripe white (sometimes split anteriorly by black line); upper labials usually 7; nasals and prefrontals separated *impar*
- Vertebral stripe black or brown; labials usually 8; nasals and prefrontals usually in contact except in southernmost *atlas*) 13
13. Back and sides brown with a total of 6 white stripes (a paravertebral, dorsolateral and midlateral on each side); midbody scale-rows 26 or fewer *piankai*
- Back and sides black or dark brown with a total of 8-22 white or brown stripes; midbody scale-rows 26 or more 14
14. White midlateral stripe (and ventrolateral stripe when present) not extending forward to level of foreleg; lateral pattern between arm and ear absent or indistinct; dark innermost dorsal stripe diverging on nape from vertebral stripe *ariadnae*
- White midlateral stripe (and ventrolateral stripe when present) extending forward nearly to ear 15
15. Head dark olive grey, variegated with black; more than 17 pale stripes including 7 on each side, which (apart from midlateral and ventrolateral) are slightly undulate and very fine; abdomen bluish white (in alcohol) *dux*
- Head brown, not variegated with black; fewer than 17 whitish stripes (none undulate or very fine); abdomen white 16
16. Whitish stripes totalling 14 (rarely 16) including 2 on each side between midlateral and dorsolateral stripes *quattuordecimlineatus*
- Whitish stripes totalling 8 (occasionally 10) with only one on each side between midlateral and dorsolateral stripes *atlas*
17. Ear lobules 2 (occasionally 3), upper semicircular and very much larger than other; first supraocular larger than second; snout extremely long and narrow, concave in plan; blackish midfrontal streak narrow and conspicuous; tail yellowish brown above, entirely white below *colletti nasutus*
- Ear lobules 2-5, graded in size; first supraocular usually smaller than second; blackish midfrontal streak absent or inconspicuous 18
18. Tail blue above, transversely marked below with black (especially proximally and ventrolaterally); series of plantars opposite fourth toe enlarged and keeled; upper labials 7 *calurus*
- Tail red above, pinkish below; no enlarged, keeled plantars; upper labials 8 *leae*
19. Back olive brown to greenish white, with black stripes variously developed but always including vertebral; white dorsolateral and midlateral stripes well developed; dark upper and lower lateral stripes enclosing large pale spots or broken by reddish vertical bars; prefrontals usually separated *schomburgkii*
- Back lustrous red (fading in alcohol to pale opalescent green or brown); black vertebral stripe and dorsal spots in juveniles, but little or no dorsal pattern in adults; white dorsolateral and midlateral stripes indistinct or absent; dark upper lateral stripe represented by series of small, squarish blotches; prefrontals usually in contact *brooksi*

Ctenotus pantherinus ocellifer

Lygosoma ocellatum Boulenger, 1896, Ann. Mag. Nat. Hist. (6) 18:223. Broome, Western Australia (K. Dahl).

Lygosoma ocelliferum [Boulenger], 1896, Ann. Mag. Nat. Hist. (6) 18:342. New name for *Lygosoma ocellatum* Boulenger, not *Lygosoma ocellatum* (Gray.)

Egernia whitei carnarae Kinghorn, 1931, Rec. Aust. Mus. 18:88. Carnarvon, Western Australia (D. G. Stead).

Lygosoma (Hinulia) breviunguis Kinghorn, 1932, Rec. Aust. Mus. 18:300. Same holotype as *E. w. carnarae*.

Diagnosis. A large, stout *Ctenotus* with short, thick tail; dorsal and lateral pattern consisting solely of ocelli; nasal grooved; subdigital lamellae sharply keeled. Distinguishable from *C. p. pantherinus* by absence of dark vertebral stripe.

Distribution. South to Atley, Goongarrie, Queen Victoria Spring and Neale Junction. Extralimital in Kimberley and North-West Divisions and Northern Territory.

Description. SVL (mm) : 32-96; males with everted hemipenes 71-83; gravid females 90-96. Length of appendages (% SVL) : tail 133-189, foreleg 21-35, hindleg 31-47.

Nasals in contact; groove from bottom of nasal up to behind nostril, whence it may continue obliquely along bottom of wide, shallow indentation in upper posterior sector of scale. Prefrontals in contact (occasionally very narrowly separated). Supraoculars 4, first 3 in

contact with frontal. Supraciliaries usually 7, occasionally 6, rarely 8. Palpebrals 9-14, first 4 keeled. Second loreal 0.7-1.4 times as wide as high. Upper labials 8 (rarely 7 or 9). Ear lobules 3-7, more acute in adults than juveniles. Nuchals 2-4. Midbody scale-rows 31-38 (usually 34 or 36). Lamellae under fourth toe 21-27, each with a fine dark keel.

Head, neck and tail olive grey or brown. Back olive in juveniles, dark brown or coppery in adults. Side of body often suffused with pink, especially inferiorly. Back and sides of body and tail with scattered ocelli, each occupying whole of a scale and consisting of central white spot or short longitudinal bar margined on each side with short black longitudinal bar. Ocelli mainly located on alternate longitudinal scale-rows and separated from each other by 2 or 3 transverse scale-rows. Dorsal ocelli beginning about level of foreleg and extending back to base of tail. Lateral ocelli extending forward nearly to ear and back nearly to middle of tail (on which white bars may coalesce to form midlateral stripe). Under surface greyish white, scales narrowly edged with pale grey.

Remarks. The holotype of *Lygosoma (Hinulia) pantherinum* Peters belongs to the small, relatively slender, rock-inhabiting southwestern race.

Material. Well 43, Canning Stock Route (R 8717); Well 35 (R 3948); 26 mi. SSE of Kidson Camp (R 26999); 59 mi. E of Well 24 (R 27008); 35 mi. W of Well 23 (R 27068); 63 mi. E of Talawana (R 27100); Pierre Spring (R 27844); Well 6 (R 27242-3); 11 mi. N of Charles Knob (R 26910); Mu Hills (ERP, 1); 12 mi. E of Barrow Range (ERP, 3); 4 mi. W of Warburton Range (R 15704); Nullye (R 25943); 64 mi. E of Cosmo Newbery (R 28879); Yamarna (R 28782); 21 mi. W of Lorna Glen (ERP, 2); 9 mi. NNE of Millrose (ERP, 7); Lake Violet (R 2765); 17 mi. S of Atley (ERP, 3); 24 mi. ENE of Laverton (ERP, 6); 5 mi. NE of Duges Table (ERP, 9); 65 mi. W of Neale Junction (ERP, 1); 31 mi. W of Neale Junction (R 27263); 8 mi. W of Neale Junction (ERP, 1); 18 mi. S of Neale Junction (ERP, 14); 8 mi. S of Goongarrie (R 26375); Queen Victoria Spring (R 17308).

Ctenotus grandis sp. nov.

Holotype. R 30005 in Western Australian Museum, formerly ERP 10904, an adult collected by Eric and Helen Pianka on 1 March 1967 at 24 miles ENE of Laverton, Western Australia, in 28° 31'S, 122° 45'E.

Diagnosis. A very large *Ctenotus* with relatively stout body and short, thick appendages; 5 dark dorsal stripes on a greenish ground (juveniles) or reddish ground (adults); sides dark with small white spots tending to be arranged in vertical bars; second loreal usually high, pentagonal, with angular apex.

Distribution. South to Atley, Agnew, Laverton and Neale Junction. Extralimital in North-West Division (north) and Northern Territory (centre and south).

Description. SVL (mm): 39-106; males with everted hemipenes 89-99. Length of appendages

(% SVL): tail 149-189; foreleg 20-28; hindleg 31-43.

Nasals separated or in contact. Prefrontals in contact (occasionally narrowly separated). Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6-10 (usually 7 or 8). Palpebrals 9-14 (mostly 10 or 11). Second loreal 0.7-1.6 times as wide as high. Upper labials 8 (rarely 7 or 9). Ear lobules 4-8; usually obtuse in juveniles and acute in adults, third mostly largest. Nuchals 1-5. Midbody scale-rows 30-34. Lamellae under fourth toe 19-26, each with a dark-brown obtuse keel or narrow callus in juveniles, and a wide, flat, pale callus in adults.

Juvenile coloration. Back, side of body and base of tail black, becoming greyish brown on head and remainder of tail. Six greenish-white stripes through centre of dorsal scales, as wide as interspaces. White centres of lateral scales vaguely arranged in vertical bars, inferiorly deflected forwards.

Adult coloration. Back dark brownish red (fading to pale brown in alcohol); head and neck olive brown; tail greyish brown. Blackish-brown vertebral stripe from nape to proximal quarter of tail. On each side two dark-brown dorsal stripes, less prominent and narrower than vertebral stripe, sometimes broken and barely discernible. Side of body dark greyish-brown flecked with white; midlaterally and ventrolaterally white marks tend to cluster and to be arranged in vertical series. Side of tail with irregular white or buff vertical bars edged with dark brown. Upper surface of limbs reddish brown, variegated on hindleg (but not foreleg) with dark and pale brown. Lips pale, sutures margined with brown. Under surface whitish.

Remarks. This species is especially notable for the great difference between juveniles and adults in dorsal coloration. In this respect juveniles resemble members of the *taeniolatus* group, while adults are remarkably similar to *Egernia striata*. The change from greenish to reddish dorsum occurs between SVL 50 and 70.

Material. Well 26, Canning Stock Route (R 3901); 10 mi. NW of Mt Beadell (R 28813); 6 mi. SW of Manunda (R 25941); 18 mi. S of Neale Junction (ERP, 2); 8 mi. W of Neale Junction (ERP, 5); 70 mi. W of Neale Junction (ERP, 2); 27 mi. ENE of Laverton (R 28830-1); 24 mi. ENE of Laverton (ERP, 44); 10 mi. NW of Agnew (ERP, 1); 17 mi. S of Atley (ERP, 3).

Ctenotus helenae sp. nov.

Holotype. R 30004 in Western Australian Museum, formerly ERP 10703, an adult collected by Eric and Helen Pianka on 23 February, 1967, at 24 miles ENE of Laverton, Western Australia, in 28° 31'S, 122° 45'E.

Diagnosis. A large member of the *lesueurii* group with moderately thick body and appendages; back dark greenish-brown; little indication of pattern except for dark vertebral stripe (which may be absent in northern specimens) and mottled flanks.

Distribution. Sandy deserts south to Laverton and Neale Junction and west to the Robertson Range, Millrose and Agnew. Extralimital in Northern Territory (western interior).

Description. SVL (mm): 34-95; males with everted hemipenes 75-86. Relative length of

appendages (% SVL): 148-226; foreleg 19-28; hindleg 32-47.

Nasals separated (just touching in one specimen). Prefrontals usually in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6-8 (mostly 7). Palpebrals 9-14 (mostly 10 or 11). Second loreal 1.0-1.9 times as wide as high. Upper labials 8 (occasionally 9). Ear lobules 4-6 (rarely 2 or 3), obtuse in juveniles, acute in adults, second or third usually largest. Nuchals 2 or 3 (4 in one specimen). Midbody scale-rows 26-33 (mostly 28 or 30). Lamellae under fourth toe 18-24, slightly compressed and narrowly callose in juveniles, uncompressed and broadly callose or smooth in adults.

Dorsal ground colour dark brown, suffused on back and base of tail with green. Black vertebral stripe usually present from nape to base of tail, seldom edged with brown paler than ground colour. Sides of body and tail greyish, flecked or dotted with black (and occasionally whitish). Occasionally an indistinct pale dorsolateral line and midlateral stripe, each narrowly edged with black. Under surface whitish, becoming bluish grey on abdomen and often suffused with grey and dotted with black under tail.

Remarks. Named after Helen Louise Pianka, who accompanied her husband on all his desert trips and assisted substantially in collecting the material that made this revision possible. *C. helenae* is closely related to *lesueurii*, which it replaces in arid, spinifex-dominated country.

Material. Swindells Field (R 29883); Robertson Range (R 25186); 9 mi. NNE of Millrose (ERP, 2); 21 mi. W of Lorna Glen (ERP, 1); 9 mi. SW of Gahnda (R 25942); 10 mi NW of Agnew (ERP, 2); 24 mi. ENE of Laverton (ERP, 53); 5 mi. NE of Dunes Table (ERP, 1); 8 mi. W of Neale Junction (ERP, 1); 18 mi. S of Neale Junction (ERP, 6).

Ctenotus Lesueurii

Tiliqua australis Gray, 1839, Ann. Nat. Hist. 2: 291. Australia. [= *Lygosoma australe* (Gray) of Peters, not *Lygosoma australis* Gray.]

Lygosoma lesueurii Duméril & Bibron, 1839 Erpétologie générale 5: 733. Australia (Péron & Lesueur).

Diagnosis. A large, slender member of the *lesueurii* group with relatively short, stout and uncompressed toes; subdigital lamellae bearing very broad, pale calli, mostly flat but proximally subtubercular; black, white-edged vertebral stripe and white, black-edged dorsolateral line always present; nasals usually separated; prefrontals usually forming long median suture; seldom more than 3 nuchals.

Distribution. Rocky hills in the Savory Creek drainage. Extralimital in much of tropical and subtropical Australia, excluding the more arid regions.

Description (including some extralimital material). SVL (mm): 39-97. Length of appendages (% SVL): tail 214-244; foreleg 20-30; hindleg 34-47.

Nasals separated (occasionally in contact). Prefrontals in contact (occasionally narrowly separated). Supraoculars 4, first 3 in contact with frontal. Supraciliaries 7 or 8. Palpebrals 9-12. Labials 8 (rarely 9). Ear lobules 4-7, obtuse in juveniles, usually long and acute in adults but occasionally truncate. Nuchals 2 or 3 (rarely 4). Midbody scale-rows 28 or 30 (rarely 26 or 32). Subdigital lamellae 19-23.

Dorsal ground colour variable; usually brown, more olive on head, more reddish on tail and limbs. Black vertebral stripe from nape to tail (on which it is paler), edged with white (occasionally very pale brown). White dorsolateral line from nape to tail (on which it is suffused with brown), occasionally extending indistinctly forward to supraciliaries, margined above and below with black. Upper lateral stripe blackish brown or grey with a series of large whitish spots or blotches partly suffused with grey or brown. Broad whitish midlateral stripe from behind axilla to tail, hardly interrupted by thigh, narrowly margined above and below with black. Limbs longitudinally streaked with dark brown. Under surface whitish.

Remarks. This skink barely penetrates the Eastern Division, and its description has been augmented with material from neighbouring parts of the North-West Division, i.e., the rocky country round the sources of the De Grey and the Fortescue.

This population could prove as worthy of recognition as is *severus*. However, it is best referred to binomially pending revision of all populations of "*lesueurii*".

Material. Robertson Range (R 25184-5); Well 24, Canning Stock Route (R 27050). [North-West Division: Mt Edgar (R 17133-4, 17156-62, 17164-5); Meentheena (R 13209); Ripon Hills (R 13244); Ragged Hills (R 13208); Mt Newman (R 25177-8, 25194, 26531).]

***Ctenotus severus* sp. nov.**

Holotype. R 25680 in Western Australian Museum, an adult collected by G. M. Storr on 27 August 1965 at Galena, Western Australia, in 27° 49' S, 114° 41' E.

Diagnosis. A moderately large member of the *lesueurii* group, closely related to *C. lesueurii* but differing in poor development of dark vertebral stripe; absence of whitish paravertebral line; dark upper lateral stripe enclosing smaller pale spots and separated by narrow interspace from white dorsolateral line.

Distribution. Southern part of Division immediately north of "Mulga-Eucalypt Line", east to Leonora-Kookynie district. Extralimital in North-West Division (southern interior) and South-West Division (northern interior).

Description (including extralimital material). SVL (mm): 44-91. Length of appendages (% SVL): tail 183-228, foreleg 19-27, hindleg 36-47.

Nasals usually separated. Prefrontals usually in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6-8 (mostly 7, rarely 6). Palpebrals 9-13 (mostly 10 or 11). Second loreal 1.0-1.8 times as wide as high. Upper labials 8 (occasionally 9). Ear lobules 3-7; obtuse in juveniles; acute, subacute or truncate in adults; second or third usually largest. Nuchals 2-4 (mostly 3). Midbody scale-rows 28-32 (usually 30). Lamellae under fourth toe 18-23, each uncompressed and bearing a broad, flat, pale brown callus (paler and higher on proximal lamellae).

Dorsal ground colour varying from bright, slightly rufous brown in east to dark grey or olive-brown in west. Vertebral stripe variously

developed but never pale-edged; usually reduced to a black or dark-brown line on neck, occasionally continuing back to base of tail, rarely broad enough to call a stripe. Blackish laterodorsal stripe from occiput or neck to proximal quarter of tail, usually much wider than adjacent dorsolateral line. Conspicuous white dorsolateral line from supraciliaries to base of tail, anteriorly and posteriorly suffused with brown, separated from dark upper lateral stripe by narrow interspace of pale grey or brown. Upper lateral stripe dark brown with pale dots or small spots of varying shape and arrangement. Pale midlateral stripe usually narrow and indistinct, extending back to groin and sometimes forward to ear. Ventrolateral streak obscure; represented on lips by brownish-grey variegations. Limbs longitudinally streaked with dark brown. Under surface whitish.

Remarks. While this taxon may prove to be a subspecies of *C. lesueurii*, its name is not *inornatus* as believed by Glauert and apparently also by Loveridge. *Hinulia inornata* Gray is a very different member of the *lesueurii* group, which Glauert redescribed as *concolor*.

Material. 7 mi. E of Leonora (R 20617); Niagara (R 15726-7); Jeedamya (R 24042); Pigeon Rocks (R 12533). [North-West Division: Landor (R 2707); 16 mi. NW of Mileura (R 20345); Mileura (R 15773, 15803, 15807, 28340); Belele (R 7370); Meka (R 29270); 24 mi. S of Cue (R 17191-2); Yalgoo (R 4948); 22 mi. SW of Yalgoo (R 17197-8); Burnerbinmah (R 13970, 13973); 18 mi. N of Paynes Find (R 18549); Fields Find (R 25637); Warriedar (R 29753); Pindabunna (R 12531-2, 17193). South-West Division: Galena (R 17195-6, 19994-6, 25680-3).]

Ctenotus leonhardii

(?) *Lygosoma* (*Hinulia*) *taeniolum* White, var. *maculata* Rosén, 1905, Ann. Mag. Nat. Hist. (7) 16:140. "West Australia" (N. Holst). [Not *Lygosoma maculatum* (Blyth).]

Lygosoma (*Hinulia*) *leonhardii* Sternfeld, 1919, Senckenbergiana 1:79. Hermannsburg, Northern Territory (M. von Leonhardi).

Diagnosis. A moderately small member of the *lesueurii* group with subdigital lamellae slightly compressed and narrowly callose; dark brown, pale-edged vertebral stripe and pale midlateral stripe always present; dark laterodorsal stripe varying in width but never enclosing pale spots; nasals usually in contact; prefrontals usually separated.

Distribution. South to Atley, Laverton, Lake Yeo, Muggun and Warburton Range. Extralimital in North-West Division (north and northeast) and Northern Territory (central and south).

Description. SVL (mm): 33-78. Length of appendages (% SVL): tail 177-241, foreleg 21-30, hindleg 40-55.

Nasals usually in contact (occasionally narrowly separated, never widely). Prefrontals usually widely separated (occasionally narrowly separated or forming very short median suture). Supraoculars 4, first 3 in contact with frontal.

Supraciliaries 6-9 (mostly 7). Palpebrals 8-13. Second loreal 1.0-2.2 times as wide as high. Upper labials 8 (rarely 9, very rarely 7). Ear lobules 3-6, usually obtuse in juveniles and subacute in adults. Nuchals 2-6 (mostly 4). Midbody scale-rows 26-31 (mostly 28). Lamellae under fourth toe 21-30, each with a brown callus.

Head and ground colour of back and sides brown; tail and upper surface of limbs paler and slightly reddish brown. Dark brown vertebral stripe from nape to base of tail, narrowly edged with pale brown. Whitish dorsolateral line from upper postocular to about middle of tail, broadly margined above with dark brown. Broad upper lateral stripe with one or two series of whitish dots. Indistinct whitish midlateral stripe from behind axilla to hindleg. Under surface whitish.

Geographic variation. The above colour description is based on the Warburton Range series and is fairly typical of specimens from the far east of the Division (and from the North-West Division and Northern Territory). In the western half of the Division, east to Mungilli and Muggun, specimens are much darker, the extreme condition being found at Atley. Here the back and sides are dark chocolate-brown, broken only by the brownish-white paravertebral line, the white dorsolateral line, one or two series of upper lateral dots and the white midlateral stripe. Because the dark laterodorsal stripe has, in effect, spread right across to the paravertebral line, the dorsal pattern at Atley is more like that of *C. piankai* than typical *leonhardii*. To the north and east of Atley, coloration is generally similar except that anteriorly the laterodorsal stripe has begun to withdraw from the paravertebral line, leaving a hiatus of pale ground colour.

Material. Weld Spring (R 27862); near Millrose (ERP, 9); Fame Range (R 21054); 3 and 11 mi. E of Mungilli Claypan (R 26896, 26898); Browne Range (R 21042); 5 mi. NW of Mt Aloysius (R 20748); Mt Eveline (R 25913); 20 mi. E of Warburton Mission (R 15705); Warburton Mission (R 14644-7, 15155, 17270-8, 17741-4, 17840-8, 22011, 22065-6, 22112, 22119-20, 22187, 22206-7, 24836); Muggun (R 15772); 30 mi. E of Stony Point (ERP, 1); 3 mi. E of Stony Point (ERP, 11); Yamarna (R 28760, 28793); 18 mi. E of Laverton (ERP, 1); Laverton (R 1234); Wanjarri (R 19767, 27225-6); Albion Downs (R 28288); 17 mi. S of Atley (ERP, 55).

Ctenotus uber sp. nov.

Holotype. R 17654 in Western Australian Museum, an adult collected by P. J. Fuller on 1 December 1962 at 22 mi. SE of Yalgoo, Western Australia, in 28°34'S, 116°52'E.

Diagnosis. A moderately small member of the *lesueurii* group with vertebral stripe reduced to a dark line; dark laterodorsal stripe enclosing a series of pale spots (as in *Egernia whitei*); and little or no trace of pale midlateral stripe. Most like *leonhardii*, from which it is further distinguishable by more numerous midbody scale-rows, separated nasals, larger prefrontals and

almost complete absence of pattern on dorsal and dorsolateral surfaces of tail.

Distribution. Patchily distributed north to Mungilli Claypan and the Rawlinson Range. Extralimital in North-West and Eucla Divisions.

Description (including extralimital material). SVL (mm) : 37-70. Length of appendages (% SVL) : tail 215-238, foreleg 22-30, hindleg 44-58.

Nasals separated. Prefrontals separated or in contact. Supraoculars 4 (rarely 3), first 3 (rarely 2) in contact with frontal. Supraciliaries 5-9 (mostly 7). Palpebrals 10-14. Second loreal 1.0-1.9 times as wide as high. Upper labials 8 (occasionally 9). Ear lobules 3-5, small and obtuse in juveniles, acute or subacute in adults. Nuchals 2-5. Midbody scale-rows 30 or 32. Lamellae under fourth toe 21-31, slightly to moderately compressed, each with a brown callus or obtuse keel.

Dorsal ground colour golden brown; darker and more olive on head; more reddish on tail and limbs. Vertebral stripe blackish brown, very narrow, not pale-edged, beginning on nape and usually extending to base of tail (occasionally disappearing a little past middle of back). Blackish-brown laterodorsal stripe from last supraocular to about level of vent, enclosing a series of pale brown spots. Whitish dorsolateral line from supraciliaries to about level of vent. Broad dark-brown upper lateral stripe from temples to base of tail, enclosing about 3 series of brownish-white dots; represented anteriorly by narrow brown loreal streak, and posteriorly by brown stripe to at least middle of tail. Pale midlateral stripe absent or barely discernible. Lower half of flanks pinkish brown dotted with white. Upper surface of limbs longitudinally streaked with brown, darker and more distinctly on hindleg. Under surface whitish.

Geographic variation. In keeping with its spotty distribution, *uber* undergoes considerable geographic variation. The material falls into three groups: (1) southern (from Yalgoo east to the Nullarbor Plain); (2) northwestern (from Jiggalong southeast to Mungilli Claypan); (3) northeastern (Rawlinson Range).

In the south the limbs are shorter; midbody scale-rows fewer (mostly 30, against, mostly 32 in northwest); toes more compressed and bearing fewer subdigital lamellae (26 or less under fourth toe, against 26 or more in the northwest) with darker and narrower calli; nasals more widely separated; prefrontals in contact or narrowly separated (well separated in northwest); nuchals more numerous (3-5, against 2-3); second loreal narrower (1.0-1.4 times as wide as high, against 1.5-1.9 in northwest).

The single specimen from the Rawlinson Range is the most peculiar in coloration. Its dark laterodorsal stripe is too narrow to enclose a series of pale spots, and it alone has indication of a pale midlateral stripe. In most other respects it agrees with the northwestern series, but its limbs are as short and its second loreal as narrow as in southern specimens.

Remark. Two of the syntypes of *Lygosoma schomburgkii* Peters resemble southern specimens of *uber* except for their well-developed pale-edged vertebral strip extending back towards end of tail. [The other syntypes, as dis-

cussed later under *C. schomburgkii*, are conspecific with *Lygosoma fischeri* Boulenger.]

Material. Mungilli Claypan (R 26894-5); 11 mi. E of Mungilli Claypan (R 26897); Pass of the Abencerrages, Rawlinson Range (R 20579); Woolgangie (R 12748); 30 mi. E of Kalgoorlie (R 7069); 15 mi. SSE of Karonie (R 17335). [North-West Division : Jiggalong (R 13341, 25118); Gnows Nest (R 17654, 26349). Eucla Division : Seemore Downs (R 17284-5); Forrest (R 17268).]

Ctenotus mimetes sp. nov.

Holotype. R 17991 in Western Australian Museum, a subadult collected by D. A. Richards on 22 October 1961 at 12 mi. E of Paynes Find, Western Australia, in 29°13'S, 117°53'E.

Diagnosis. A moderately small member of the *lesueurii* group with back brown and unpatterned except for black laterodorsal stripe, which is unspotted and not much wider than adjacent white dorsolateral line; conspicuous narrow white midlateral stripe separating dark upper and lower lateral zones, each of which encloses a series of large pale spots. Further distinguishable from *severus* by more slender and compressed toes, with lamellae more numerous and narrowly callose.

Distribution. Far western semiarid zone north to lat. 29°S. Extralimital in North-West Division and South-West Division (north and east).

Description (including extralimital material). SVL (mm): 33-79. Length of appendages (% SVL): tail 193-280, foreleg 22-30, hindleg 45-56.

Nasals widely separated. Prefrontals in contact (occasionally narrowly separated). Supraoculars 4, first 3 in contact with frontal. Supraciliaries 5-8 (mostly 7). Palpebrals 10-14. Second loreal 1.0-1.9 times as wide as high. Upper labials 8 (occasionally 9). Ear lobules 4 (occasionally 3 or 5), obtuse in juveniles, subacute in adults, second usually largest. Nuchals 3 or 4. Midbody scale-rows 26 or 28 (32 in one specimen). Lamellae under fourth toe 23-28, each compressed and bearing a narrow dark-brown callus or obtuse keel.

Dorsal ground colour brown, duller anteriorly, brighter and redder posteriorly (including upper surface of hindleg). Dorsal pattern restricted to narrow black laterodorsal stripe from central supraciliaries to base of tail, whence it may extend (as a series of small dark-brown spots) to proximal third of tail. White dorsolateral line from supraoculars to middle of tail (on which it is suffused with pink), in contact with black laterodorsal and upper lateral stripes. Broad black upper lateral stripe from orbit to base of tail, enclosing large pale spots of varying shape and colour (usually whitish, largely suffused with reddish brown, and occupying more space than black background and tending to be oblong and vertically elongate). White midlateral stripe, no wider than white dorsolateral line, extending from lores to groin, whence (becoming wider and reddish) it runs along inner surface of thigh; represented on tail by moderately wide ventrolateral stripe. Lower lateral pattern similar to upper lateral but narrower and less regular. Limbs reticulated

with blackish brown. Sutures between labials narrowly margined with brown. Under surface white.

Remarks. The resemblance in dorsal pattern between this species and *C. labillardieri* has led to erroneous northern and inland records of the latter species. More remarkable is the resemblance in lateral pattern between *mimetes* and *schomburgkii*.

Material. 42 mi. S of Youanmi (R 19119). [North-West Division: Duck Creek, Wyloo (R 13211); 12 mi. E of Paynes Find (R 17991); 44 mi. NE of Paynes Find (ERP, 1). South-West Division: 20 mi. NE of Yuna (R 26499); Yuna (R 8303, 9021); Carnamah (R 407); Merredin (R 1265-6).]

***Ctenotus dux* sp. nov.**

Holotype. R 30002 in Western Australian Museum, formerly ERP 11269, an adult collected by Eric and Helen Pianka on 6 May 1967 at 5 miles NE of Dunes Table, Western Australia, in 28°08'S, 123°55'E.

Diagnosis. A moderately large member of the *taeniolatus* group with a total of about 20 white and brown dorsal and lateral stripes on a black ground (with growth, brown dorsal stripes spread laterally at expense of black ground so that dorsum of adults is better described as brown, striped with black). Further distinguishable from *ariadnae* by clearer-cut lateral pattern, especially anteriorly (where white midlateral and ventrolateral stripes extend forward nearly to ear), and from *quattuordecimlineatus* by narrower and more numerous white lateral lines (including one between midlateral and ventrolateral white stripes).

Distribution. Sandy deserts from the Mu Hills south and west to Dunes Table and Lorna Glen. Extralimital in Northern Territory (south).

Description. SVL (mm): 32-64. Length of appendages (% SVL): tail 176-226, foreleg 25-32, hindleg 42-54.

Nasals usually in contact. Prefrontals in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries usually 7, occasionally 6, rarely 8. Palpebrals 9-13. Second loreal 1.0-1.9 times as wide as high. Upper labials 8 (occasionally 9). Ear lobules 2-6, usually obtuse in juveniles and acute in adults. Nuchals 2-4 (mostly 3). Midbody scale-rows 28-32. Lamellae under fourth toe 23-30, each with a dark brown callus or obtuse keel.

Dorsal ground colour brown (tinged with reddish or metallic olive) becoming darker and more olive on head, and paler and more buffy on tail and upper surface of limbs. Prominent black vertebral stripe from nape (where it is narrow) to base of tail, narrowly edged with pale brown or brownish white. Black laterodorsal stripe from last supraocular to proximal third of tail, almost as wide as vertebral stripe, narrowly and more or less obscurely margined above with pale brown. Dorsal zone between these black stripes (and their pale margins) variously marked with black. Immediately below laterodorsal stripe, a narrow but prominent white dorsolateral stripe from upper postocular to distal quarter of tail. Sides black with 7 white lines or stripes, the widest of which are the lowest (ventrolateral) and third-lowest

(midlateral); remainder wavy and very narrow. Midlateral white stripe extending from below and in front of eye to middle of tail, interrupted by ear aperture and almost completely by thigh. Ventrolateral white stripe from below and behind ear to groin, interrupted by arm. Head variegated with blackish. Sutures between labials margined with black or blackish brown. Limbs streaked with dark brown. Under surface bluish white (in alcohol), darkest on abdomen.

Material. Mu Hills (ERP, 1); 56 mi. SW of Warburton Range (ERP, 1); Muggun (R 15721); Nullye (R 20705); Lake Throssell (ERP, 1); Yamarna (R 28785-8); 5 mi. NE of Dunes Table (ERP, 36); 21 mi. W of Lorna Glen (ERP, 8).

***Ctenotus ariadnae* sp. nov.**

Holotype. R 30006 in Western Australian Museum, formerly ERP 10667, an adult collected by Eric and Helen Pianka on 22 February 1967 at 24 miles ENE of Laverton, Western Australia, in 28°31'S, 122°45'E.

Diagnosis. A moderately large member of the *taeniolatus* group closely related to *dux* and *quattuordecimlineatus* but distinguishable from both by its shorter appendages, paler coloration and almost complete lack of lateral pattern between ear and foreleg (especially failure of white midlateral and ventrolateral stripes to extend anteriorly beyond arm).

Distribution. From Well 30 (Canning Stock Route) south nearly to Laverton.

Description. SVL (mm) : 29-64. Length of appendages (% SVL) : tail 162-186, foreleg 21-30, hindleg 34-47.

Nasals in contact. Prefrontals in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6 or 7. Palpebrals 9-12. Second loreal 1.0-2.0 times as wide as high. Upper labials 8. Ear lobules 4-7, obtuse in juveniles, long and acute in adults. Nuchals 1-4. Midbody scale-rows 29-34. Lamellae under fourth toe 20-24, each with a narrow brown callus or obtuse keel.

Head olive grey or brown. Tail and limbs pale reddish brown. Back and sides dark brown (adults) or blackish (juveniles) with about 18 pale lines or stripes well-defined dorsally but increasingly ill-defined on sides. Pale brown paravertebral line from nape to middle of tail. Pale brown dorsal line from nape to base of tail. Whitish dorsolateral line from above temples or ear to distal part of tail (on which it is wider and suffused with brown). 3 or 4 pale-brown upper lateral lines, upper extending anteriorly almost to level of ear, lower not reaching forward to or past level of arm. White midlateral stripe more or less narrow and indistinct, not reaching forward to axilla. Pale ventrolateral stripe indistinct or absent, not reaching forward to axilla. Underneath whitish except for greyish lateral margins of ventrals (and sometimes also of gulars).

Remarks. Named after Mrs Ariadna Neumann (Librarian, Western Australian Museum) in appreciation of the many translations she has done for me.

Material. Well 30, Canning Stock Route (R 3917); 60 mi. E of Dunes Table (ERP 10429); White Cliffs (R 20660); 24 mi. ENE of Laverton (ERP 10765, 10796, 10802).

Ctenotus quattuordecimlineatus

Lygosoma (Hinulia) quattuordecimlineatum Sternfeld, 1919, *Senckenbergiana* 1:80. Hermannsburg, Northern Territory (M. von Leonhardi).

Diagnosis. A moderately large member of the *taeniolatus* group with a total of 14 or 16 whitish dorsal and lateral stripes on a blackish ground. Distinguishable from *atlas* by having at least 2 white lines (against one) between white dorso-lateral and midlateral stripes; from *ariadnae* by midlateral and ventrolateral white stripes extending forward beyond arm; and from *dux* by midlateral and ventrolateral white stripes wider than black interspace (which does not bear a white line).

Distribution. Sandy deserts north to about latitude 21°S, west nearly to Laverton and south to Queen Victoria Spring. Extralimital in Northern Territory (south).

Description. SVL (mm) : 29-70. Length of appendages (% SVL) : tail 191-240, foreleg 22-33, hindleg 38-53.

Nasals in contact (rarely separated). Prefrontals in contact (very rarely separated). Supraoculars 4, first 3 in contact with frontal. Supraciliaries 7 (occasionally 6 or 8). Palpebrals 9-13. Second loreal 1.0-2.1 times as wide as high. Upper labials 8 (rarely 7 or 9). Ear lobules 2-7, usually obtuse in juveniles and acute in adults. Nuchals 1-8 (mostly 2 or 3). Midbody scale-rows 26-30. Lamellae under fourth toe 21-28, each with a dark brown callus or obtuse keel.

Ground colour of head, tail and upper surface of limbs brown (tail and lower back sometimes suffused with reddish). Back and sides dark brown to blackish, with 14 or 16 white lines and stripes, often suffused on back (but rarely on sides) with brown. Line through centre of paravertebral scales from nape to middle of tail (on which it becomes broader and darker). Line through centre of adjacent dorsal scales from nape to base of tail, where it is joined by dorso-lateral line (beginning above and behind eye) and 2 lines beginning above and behind ear; resultant dorsolateral stripe on tail similar in width, extent and colour to paravertebral stripe. Midlateral stripe from below eye to middle of tail, interrupted by ear aperture, passing well above arm, and partly interrupted by thigh. Ventrolateral stripe beginning below and behind ear, partly interrupted by arm, ending at or before groin. Under surface white.

Material. Well 35, Canning Stock Route (R 3949); 28 mi. SW of Warburton Mission (R 18003); Nullie (R 20706); 64 mi. E of Cosmo Newbery (R 28821-2); 24 mi. ENE of Laverton (ERP, 45); 5 mi. NE of Duges Table (ERP, 6); 60 mi. E of Duges Table (ERP, 2); 8 mi. W of Neale Junction (ERP, 1); 18 mi. S of Neale Junction (ERP, 34); Queen Victoria Spring (R 12955, 13030, 18001).

Ctenotus atlas sp. nov.

Holotype. R 30001 in the Western Australian Museum, formerly ERP 10507, an adult male collected by Eric and Helen Pianka on 30 January 1967 at 17 miles south of Atley, Western Australia, in 28°27'S, 119°05'E.

Diagnosis. A moderately large member of the *taeniolatus* group with a total of 8 or 10 pale dorsal and lateral stripes on a blackish ground.

Distinguishable from *impar* by lack of pale vertebral stripe, and from *quattuordecimlineatus*, *ariadnae* and *dux* by having no more than one fully developed pale line between white dorso-lateral and midlateral stripes.

Distribution. The slightly more humid southwestern part of the Division, from Atley south to Woolgangie and east to Queen Victoria Spring. Extralimital in North-West Division (upper Ashburton) and western South Australia (near Lake Everard).

Description. SVL (mm): 31-68.5. Length of appendages (% SVL): tail 191-226, foreleg 22-31, hindleg 38-53.

Nasals usually in contact. Prefrontals in contact (occasionally separated in south). Supraoculars 4, first 3 in contact with frontal. Supraciliaries 7 (occasionally 6). Palpebrals 9-14. Second loreal 1.1-2.0 times as wide as high. Upper labials 8 (rarely 9). Ear lobules 2-7 (mostly 3 or 4). Nuchals 1-4. Midbody scale-rows 28-34. Lamellae under fourth toe 21-27, each with a narrow dark-brown callus.

Ground colour of back and sides blackish brown; of head, tail and upper surface of limbs dark brown. Brownish-white line through centre of paravertebral scales from nape to base of tail. White dorsolateral line from eye to proximal third of tail (on which it becomes wider and brownish). Brownish-white line from above and behind ear to base of tail. White midlateral stripe from ear to proximal half of tail, passing well above arm and slightly interrupted by thigh. Usually a total of 8 pale stripes or lines on body; occasionally 10, due either to interpolation of an obscure pale-brown line between paravertebral and dorsolateral lines or to presence of white ventrolateral stripe. Lower lips and under surface white.

Remarks. This is the species referred to by Glauert (1961 : 68) as "*Lygosoma (Sphenomorphus) leae*".

Material. 17 mi. S of Atley (ERP, 23); 10 mi. NW of Agnew (ERP, 1); 2 mi. S of Goongarrie (R 26373-4); Woolgangie (R 12744); 8 m. N of Coolgardie (R 19139); Kalgoorlie (R 10252); 12 mi. NW of Cundeelee (R 13039); Cundeelee (R 21702); Queen Victoria Spring (R 12956).

Ctenotus impar sp. nov.

Holotype. R 1333 in Western Australian Museum, an adult collected by F. R. Bradshaw in 1924 at Tambellup, Western Australia, in 34°02'S, 117°38'E.

Diagnosis. A moderately large member of the *taeniolatus* group with a total of 11 pale dorsal and lateral stripes on a black ground, including a broad whitish vertebral stripe. Further distinguishable by "capture" of anterior end of dorsolateral white line by midlateral white stripe.

Distribution. Far southwest corner of the Division. Extralimital in South-West Division (southern half).

Description. (including extralimital material). SVL (mm): 32-66. Length of appendages (% SVL) : tail 177-198, foreleg 21-28, hindleg 36-47.

Nasals separated. Prefrontals separated. Supraoculars 4, first 3 (abnormally 2) in contact with frontal. Supraciliaries 7 (occasionally 6). Palpebrals 8-12. Second loreal 0.9-1.6 times

as wide as high. Upper labials 7 (rarely 6 or 8). Ear lobules 2-5, mostly 3 or 4, second usually largest. Midbody scale-rows usually 28, occasionally 26, rarely 30. Lamellae under fourth toe 18-25, each with a wide dark-brown callus.

Ground colour of head, tail and upper surface of limbs brown. Back and sides black with following pale lines or stripes. Broad greyish-white or brownish-white vertebral stripe from nape to base of tail, occasionally split by median black line. Dorsal line of similar colour from occiput to proximal quarter of tail, its anterior extension deflecting inwards to rear of frontal and outwards along edge of frontal to prefrontal. White outer dorsal line from above eye to middle of tail (on which it becomes pale brown). White dorsolateral line from above and behind ear to middle of tail (on which it becomes brownish). White midlateral stripe extending forward nearly to ear where it forms T-junction; upper branch going above ear and forward to orbit on alignment of dorsolateral line; lower branch joining ventrolateral stripe which extends back to groin after interruption at arm. After interruption by ear aperture midlateral stripe continues forward along labials nearly to nostril. Under surface white.

Remarks. Presumably because of its 11 whitish stripes, Glauert (1961:69) identified this species with *undecimstriatus* (Kuhl). However Kuhl (1820:129) was alluding to 11 brown stripes, which implies a total of 10 whitish stripes. The specimens described by Kuhl were in the British and Paris Museums and doubtless would have been seen by Boulenger (1887:227) and Duméril & Bibron (1839:735) when they synonymised *Scincus undecimstriatus* with *Lygosoma taeniolatum*.

Material. No. 5 Pumping Station, Goldfields Pipe-Line (R 8826); "Queen Victoria Spring" (R18000). [South-West Division: Mooliabeenee (R 17999); "Cottesloe" (R 125-6); Bellevue (R 1775); 15 mi. SE of Karragullen (R 17998); Pinjarra (R 29229); Busselton (R 27864-5); Williams (R 4712); Narrogin (R 7765); Tambellup (R 1349, 1352, 1629, 1867, 2101, 2330); Ongerup (R 2534); Jerramungup (R 17996-7).]

***Ctenotus piankai* sp. nov.**

Holotype. R 30000 in Western Australian Museum, formerly ERP 10799, an adult male collected by Eric and Helen Pianka on 26 February 1967 at 24 miles ENE of Laverton, Western Australia, in 28°31'S, 122°45'E.

Diagnosis. A small member of the *taeniolatus* group with a total of 6 white dorsal and lateral stripes on a brown ground.

Distribution. Great Victoria Desert, north to Muggun and west nearly to Laverton. Extralimital in Kimberley Division (far southwest) and Northern Territory (western interior).

Description. SVL (mm) : 30-46. Length of appendages (%SVL) : tail 190-233, foreleg 26-31, hindleg 43-49.

Nasals in contact. Prefrontals usually in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6 or 7 (rarely 8). Palpebrals 9-12. Second loreal 1.0-1.7 times as wide as high. Upper labials 8. Ear lobules 1-5. Nuchals 2-4. Midbody scale-rows 24 (occasionally 26).

Lamellae under fourth toe 19-26, each with a narrow dark-brown callus (higher proximally).

Dorsal ground colour brown, darkest on back, palest on tail and snout. White line through centre of paravertebral scales from nape to base of tail. White dorsolateral line from temples to middle of tail (on which it is suffused with brown). White midlateral stripe from ear to proximal quarter of tail. Dark interspace between dorsolateral line and midlateral stripe may be finely dotted with white in juveniles. Lips and under surface white except for darkening under digits.

Remarks. Named after Dr Eric R. Pianka, in appreciation of his intensive research on the ecology of our desert lizards.

Material. Muggun (R 15723); 24 mi. ENE of Laverton (ERP, 1); 5 mi. NE of Dungen Table (ERP, 1); 8 mi. W of Neale Junction (ERP, 5); 18 mi. S of Neale Junction (ERP, 2).

Ctenotus leae

Lygosoma leae Boulenger, 1887, Cat. Liz. Brit. Mus. 3:226. "Adelaide (T. E. Lea)."

Diagnosis. A large member of the *colletti* group with an extremely long, red tail.

Distribution. Great Victoria Desert.

Description. SVL (mm) : 39-60. Length of appendages (%SVL) : tail 240-262, foreleg 23-32, hindleg 50-58.

Nasals in contact. Prefrontals usually in contact. Supraoculars 4, first 3 (rarely 2) in contact with frontal. Supraciliaries 7 (occasionally 6, rarely 8). Palpebrals 9-12. Second loreal 1.0-1.5 times as wide as high. Upper labials 8. Ear lobules 2-5, usually obtuse or subacute, second usually largest. Nuchals 2-5. Midbody scale-rows 21-26. Lamellae under fourth toe 24-29, each with a sharp, mucronate, dark-brown keel.

Vertebral stripe from nape to proximal quarter of tail, black on back, dark brown on tail; narrowly margined with white on back and pinkish brown on tail (this margin, or paravertebral line, extends forward in a series of blotches and broken lines to frontoparietal, thence along edge of posterior half of frontal). Laterodorsal stripe from nape to base of tail, at first black, then dark reddish brown, margined below by white dorsolateral line from last supraocular to middle of tail (on which it is suffused with pinkish brown). Dark upper lateral stripe from orbit to distal quarter of tail, at first narrow and blackish brown, on side of body broad and black, on side of tail narrower and paler. Broad white midlateral stripe from loreals to thigh. Narrow brownish-black ventrolateral stripe from axilla to groin; anteriorly from arm it forks, upper and wider branch extending nearly to ear, lower branch discontinuously to below ear or a little beyond. Distal half of tail bright brownish red. Top of head dark olive grey, paler and browner on snout. Narrow white streak from orbit to temples. Narrow dark-brown streak from behind nostril to above ear, where it usually joins upper lateral stripe. Sutures between anterior labials pale greyish-brown. Under surface milky white, increasingly suffused with pink under tail.

Remarks. Apart from its coloration and slightly greater size (SVL 61.5), the type of *leae*

agrees perfectly with 17 specimens from Duges Table. Where the latter are black and red, the type is respectively dark and pale brown. These differences are almost certainly due to fading in the type; if so, it must have been collected several years before Boulenger examined it.

Material. 5 mi. NE of Duges Table (ERP, 17); Queen Victoria Spring (R 13031); 65 mi. W of Neale Junction (ERP, 1).

***Ctenotus calurus* sp. nov.**

Holotype. R 30003 in Western Australian Museum, formerly ERP 10788, an adult collected by Eric and Helen Pianka on 26 February 1967 at 24 miles ENE of Laverton, Western Australia, in 28°31'S, 122°45'E.

Diagnosis. A small member of the *colletti* group with tail blue above and white below marked transversely with black (most pronounced proximally and ventrolaterally). Further distinguishable by series of enlarged, keeled scales on sole opposite fourth toe.

Distribution. Sandy deserts south to Queen Victoria Spring and west to the McConkey Hills and Millrose. Extralimital in North-West Division (southeast of Exmouth Gulf) and Northern Territory (south).

Description. SVL (mm) : 26-49. Length of appendages (% SVL) : tail 181-238, foreleg 23-30, hindleg 44-55.

Nasals in contact (rarely separate). Prefrontals in contact. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6-8. Palpebrals 8-12. Second loreal 1.5-2.2 times as wide as high. Upper labials 7. Ear lobules 3-5, obtuse in juveniles, more acute in adults, second usually largest. Nuchals 1-5 (mostly 3 or 4). Midbody scale-rows 24-27. Lamellae under fourth toe 20-24, each with a fine sharp keel; distal lamellae mucronate; proximal lamellae less compressed, similar to and continuous with enlarged plantars.

Back and sides with alternating black and white stripes. Widest of 9 black stripes are upper lateral and vertebral; ventrolateral narrowest. Widest of 8 white stripes is midlateral; others are lines through centre of dorsal scales. Black vertebral stripe from nape to proximal third or middle of tail (on which it is narrower and paler). Upper lateral black stripe begins narrowly behind nostril, passes through lower eyelid back nearly to end of tail, after sending branch down upper surface of hindleg. Midlateral white stripe from ear to hindleg. Black ventrolateral stripe from behind bottom of ear to groin, thence along inner surface of hindleg. Distal half of tail bright blue in juveniles, greyish blue in adults. Top of head coppery brown, variegated with blackish; paler and pinkish on snout. Lips and under surface white except for small black spots under toes and black edges to anterior subcaudals (especially prominent ventrolaterally).

Material. 37 mi. W. of Windy Corner (R 27007); 11 mi. N of Charlies Knob (R 26911); south of McConkey Hills (R 27863); 21 mi. W of Lorna Glen (ERP, 10); 9 mi. NNE of Millrose (ERP, 1); 24 mi. ENE of Laverton (ERP, 7); Yamarna (R 29219); 5 mi. NE of Duges Table (ERP, 4); 16 mi. ENE of Duges Table (ERP,

1); 8 mi. W of Neale Junction (ERP, 4); 18 mi. S of Neale Junction (ERP, 3); Queen Victoria Spring (R 12957).

***Ctenotus colletti nasutus* subsp. nov.**

Holotype. R 30250 in Western Australian Museum, formerly ERP 11331, an adult collected by Eric and Helen Pianka on 8 May 1967 at 5 miles NE of Duges Table, Western Australia, in 28°08'S, 123°55'E.

Diagnosis. A small member of the *colletti* group with tail pale brown above, entirely white below; snout concave in plan and extremely long, low and narrow; first supraocular largest; upper ear lobule greatly enlarged ("opercle-like"); prominent dark midfrontal streak. Distinguishable from *C. c. colletti* (Boulenger) of far southwest of Kimberley Division by having 5 dark dorsal stripes, of which the vertebral is much the widest, instead of 7 equally narrow dark stripes.

Distribution. Great Victoria Desert. Extralimital in Northern Territory (southwest).

Description. SVL (mm): 34-45. Length of appendages (% SVL): tail 192-243; foreleg 24-29; hindleg 40-49.

Nasals in contact. Prefrontals usually in contact. Supraoculars 4 (5 in one specimen), first 3 in contact with frontal, first largest (except when divided). Supraciliaries 6. Palpebrals 9-11. Second loreal 1.5-1.9 times as wide as high. Upper labials 7 or 8. Ear lobules 2 (occasionally 3), upper semicircular and much the larger. Nuchals 3 or 4. Midbody scale-rows 22-26. Lamellae under fourth toe 22-29, mostly with a fine, dark, mucronate but relatively weak keel (keels weakest or absent on proximal lamellae).

Back and sides with alternating dark and pale stripes. Widest of 9 blackish stripes are upper lateral and vertebral. Widest of 8 white stripes is midlateral; others are merely greenish or reddish white lines through centre of dorsal scales. Blackish-brown vertebral stripe from nape to end of tail (on which it becomes paler and narrower). Other dorsal stripes end on base of tail. White dorsolateral line beginning above and behind eye. Blackish-brown upper lateral stripe from anterior edge of nasal nearly to end of tail, interrupted by orbit and almost contacting upper surface of thigh. White midlateral stripe from above ear to groin. Lowest dark stripe (ventrolateral) narrow, indistinct, extending back from axilla to groin and forward above arm nearly to ear. Head yellowish brown with blackish-brown markings, most prominent of which is median streak on frontal, extending back to anterior edge of interparietal and forward to posterior third of frontonasal. Lips and under surface white except for greyish suffusion under digits.

Remarks. The specimens of "*colletti*" reported by Loveridge (1934 : 347) actually belong to *C. schomburgkii*. Glauert's concept of "*colletti*" (1961 : 69) was based on a *calurus* and a juvenile *grandis* from Marrilla and three specimens of an undescribed member of the *taeniolatus* group from Wotjulum (I have not seen his Abydos specimen).

Material. 5 mi. NE of Duges Table (ERP 12294, 13135); 65 mi. W of Neale Junction (ERP,

13097). [Northern Territory : Davenport Hills (JSE 219); 21 mi. E of Sandy Blight Junction (ERP 11551).]

Ctenotus schomburgkii

Lygosoma schomburgkii Peters, 1863, Mber. Akad. Wiss. Berlin 1863 : 231 "Buchsfield, near Adelaide, South Australia (R. Schomburgk)."

Hinulia muelleri Fischer, 1882, Arch. Naturgesch. 48(1): 295. Nickol Bay, Western Australia (F. von Mueller).

Lygosoma fischeri Boulenger, 1887, Cat. Liz. Brit. Mus. 3 : 228. [Based on *Lygosoma muelleri* (Fischer), not *Lygosoma muelleri* (Schlegel).]

Diagnosis. A member of the *schomburgkii* group whose dorsal coloration is variable but never bright red; black vertebral stripe and whitish dorsolateral line always present; prefrontals usually separated; anterior preocular not in contact with subocular labial.

Distribution. North to Windich Spring, Alexandra Spring and Mt Eveline. Extralimital in North-West, South-West (northeast) and Eucla Divisions and in Northern Territory (southwest).

Description. SVL (mm) : 26-51.5. Length of appendages (% SVL) : tail 151-215, foreleg 21-31, hindleg 41-56.

Nasals usually separated. Prefrontals usually separated. Supraoculars 4, first 3 in contact with frontal. Supraciliaries 6-9 (mostly 7, seldom 8 or 9). Palpebrals 8-11. Second loreal 1.1-2.4 times as wide as high. Upper labials 7 (occasionally 8). Ear lobules 1-5, usually obtuse, first or second often much larger than others. Nuchals 3 or 4 (rarely 5). Midbody scale-rows 24-30 (mostly 26 or 28). Lamellae under fourth toe 17-26, each with a fine, sharp, dark keel terminating in a mucron.

Eastern colour-type (based on lectotype). Head olive green. Tail olive or bronze brown. Back black with 4 greenish-white lines: paravertebrals continuous and considerably narrower than black vertebral stripe; laterodorsals broader than adjacent black lines and apt to be broken into series of small spots. Whitish dorsolateral line extending back on to tail and forward to orbit and less distinctly along supraciliaries. Whitish midlateral line extending back on to tail and forward nearly to nasal, after bending up and round ear aperture. Between dorsolateral and midlateral lines a black upper lateral stripe from orbit to middle of tail, enclosing a series of large, pale, vertically or obliquely elongate spots suffused with red or green; represented on snout by blackish streak from nasal to orbit. Black ventrolateral stripe enclosing pale spots and extending back narrowly on to tail and forward (as a row of dark brown smudges) on lower half of upper labials. Limbs pale reddish-brown reticulated with dark brown. Under surface white.

Western colour-type (based on Atley series). Head dark olive brown. Tail pale greyish-brown. Back variously olive green, grey or brown. Black vertebral stripe from nape to proximal quarter of tail. Black laterodorsal line from upper postocular to base of tail, occasionally broken. Remainder of back variously marked with black, but usually so disposed as to leave pale margin to vertebral stripe and to form one or two lines of spots or short bars on each side. Immediately below laterodorsal line a white dorsolateral line

from temples to base of tail. White midlateral line from below eye to base of tail. Between midlateral and dorsolateral lines (and on temples as well as side of body) a series of alternating black and reddish vertical bars; represented on snout by blackish streak from nasal to orbit. Lower lateral series of bars similar to upper lateral, but not so regular and often smaller.

Geographic variation. At first it seemed possible to divide *schomburgkii* into two races on the basis of the above colour variation: a western race (*fischeri*) with dorsal pattern obscurely striped, lateral pattern fenestrate and femoral pattern striped; and an eastern race (nominate *schomburgkii*) with dorsal pattern clearly striped, lateral pattern spotted and femoral pattern reticulate. However, the presence of numerous, variously intermediate populations makes such a division impracticable.

The western colour-type, in its pure form, is confined in the Eastern Division to the far west. Immediately east of longitude 120, there begins a gradual change towards eastern coloration. Beyond longitude 124 eastern characters predominate, but even at Neale Junction (126°E) western characters are common. It is only in the northeast of the Division (and adjacent parts of the Northern Territory) that we invariably find the eastern colour-type.

Within this broad zone of intergradation, correlation is generally poor between the various characters. Round Zanthus, for example, specimens usually combine a western dorsal pattern with an eastern lateral pattern. The picture is further complicated by ontogenetic change: the tendency for juveniles to have eastern coloration, and for adults of the same population to have western.

Remarks. The four syntypes of *schomburgkii* (Berlin 4713) comprise two species. Two specimens belong to the *lesueurii* group, and two to the present species. The larger of the latter specimens (SVL 45 and 26) is here designated lectotype of *schomburgkii*.

Material. Windich Spring (R 27859); 9 mi. NNE of Millrose (ERP, 5); Wiluna (MCZ 33275); 17 mi. S of Atley (ERP, 34); 15 mi. ENE of Laverton (ERP, 1); 24 m. ENE of Laverton (ERP, 5); Yamarna (R 17269, 28783-4); 5 mi. NE of Dungen Table (ERP, 9); 3 mi. E of Stony Point (ERP, 2); 18 mi. N of Alexandra Spring (R 28861); Mt Eveline (R 17279); 50 mi. S of Warburton Mission (R 15175); 18 mi. S of Neale Junction (ERP, 6); Queen Victoria Spring and 15 mi. S (R 17267, 12238); 12 and 15 mi. NW of Cundeelee (R 13040, 21672); 10 mi. E of Zanthus (R 17283); 41 mi. SSE of Karonie (R 17337-8).

Ctenotus brooksi

Sphenomorphus leae brooksi Loveridge, 1933, Occ. Pap. Bost. Nat. Hist. 8: 95. "Perth, Western Australia (W. S. Brooks)."

(?) *Lygosoma* (*Sphenomorphus*) *taeniata* Mitchell, 1949, Rec. S. Aust. Mus. 9: 180. Andamooka, South Australia (F. J. Mitchell).

Diagnosis. A number of the *schomburgkii* group with head and back red; little or no indication of stripes; prefrontals usually in contact; anterior preocular usually in contact with subocular labial; plantar scales opposite fourth toe similar in appearance to proximal lamellae.

Distribution. Sandy deserts north to lat 23° S and west to Weld Spring, Lake Throssell and Queen Victoria Spring. Extralimital in Northern Territory (south) and (?) northern South Australia.

Description. SVL (mm) : 26-50. Length of appendages (% SVL) : tail 160-212, foreleg 23-34, hindleg 44-55.

Nasals separated or just touching (seldom forming a median suture). Prefrontals in contact (seldom separated and then usually very narrowly). Supraoculars 4 (occasionally 5, when first transversely divided), first or second largest, first 3 in contact with frontal (4 when first divided). Supraciliaries 6 or 7 (mostly 7). Palpebrals 8-12 (mostly 9 or 10). Second loreal 1.3-2.3 times as wide as high. Upper labials 7 or 8. Ear lobules 2-5, obtuse in juveniles, longer and sharper in adults, second usually largest. Nuchals 0-4. Midbody scale-rows 24-28 (mostly 24 and 26). Lamellae under fourth toe 21-28, each with a fine sharp keel terminating in a mucron.

Head and back crimson or coral-red in life, fading in alcohol quickly to opalescent green and finally to lustrous pale brown. Tail and upper surface of limbs buffy brown. Narrow vertebral stripe from neck to base of tail, blackish and sharply defined in juveniles, increasingly pale and indistinct in adults. Remainder of back with small scattered spots anteriorly tending to align, blackish brown in juveniles, much paler in subadults and barely discernible in largest specimens. Upper half of flanks with blackish-brown blotches, usually arranged in a series of about

20 irregularly vertical bars from neck to hindleg; represented on tail by brownish-grey dorso-lateral stripe extending to tip. Upper surface of limbs with greyish stripes, darker and better defined on hindleg than foreleg. Upper lips white with pale grey sutures. Under surface white (abdomen bright blue in alcohol).

Remarks. Despite its improbable locality, the type of *brooksi* clearly belongs here. The type of *taeniata* is unique in having 8 supraciliaries and weakly keeled subdigital lamellae; perhaps it comes from an isolated population.

Material. 17 mi. N of Weld Spring (R 15856); 15 mi. N of Alexandra Spring (R 28855); Mu Hills (ERP, 2); W and N of Mt Aloysius (ERP, 4); 20 mi. E of Barrow Range (ERP, 8); near Warburton Mission (R 15150, 15175, 22059); 50 mi. S of Warburton Mission (R 15173-4); 30 and 54 mi. SW of Warburton Mission (ERP, 7); near Lake Throssell (ERP, 2); 5 mi. NE of Duges Table (ERP, 28); Queen Victoria Spring (R 21699).

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11.—Microplankton from two samples from Gingin Brook No. 4 Borehole, Western Australia

by Isabel C. Cookson¹ and A. Eisenack²

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Abstract

Twenty-eight species of dinoflagellates assignable to 25 genera are recorded from Cretaceous strata of the Perth Basin, Western Australia. Two new genera are instituted. These are *Anthosphaeridium* (type species: *A. convolvuloides* Cookson and Eisenack n.sp.) and *Heterosphaeridium* (type species: *H. conjunctum* Cookson and Eisenack n.sp.). The following 6 new species are described: *Deflandrea lata*, *Ascedinium lordi*, *Aptecdinium cribosum*, *Hystriosphera paradoxa*, *Anthosphaeridium convolvuloides*, and *Heterosphaeridium conjunctum*.

Introduction

The present paper is concerned with the microplankton content of two Cretaceous samples of Gingin Brook No. 4 Borehole, drilled by the Geological Survey of Western Australia. The borehole is situated at latitude 31° 19' 15" South, longitude 115° 32' 47" East, about 20 miles west of Gingin, a townsite some 45 miles north of Perth. The upper of these, from between 202 and 204 feet, represents the silty limestone unit, rich in foraminifera, which occurs between 180 and 215 feet (Sanders 1967). The lower sample, a glauconitic carbonaceous claystone, represents the interval between 404 and 414 feet.

The microplankton assemblages present in these two samples are so distinct from one another that they will be considered herein under separate headings. The samples and information concerning them were generously supplied by Mr. J. H. Lord, Director of the Geological Survey of Western Australia.

The holotypes will be housed in the palaeontological collection of the Geological Survey of Western Australia. Numbers prefaced by the letter F are registered numbers in that collection.

Systematic descriptions

1. Gingin Brook No. 4 Borehole between 202 and 204 feet

The age suggested for the silty limestone at this depth is Upper Cretaceous, either lowest Campanian or possibly Santonian (A. E. Cockbain in Sanders 1967, p. 30).

Dinoflagellata

Family DEFLANDREACEAE Eisenack

Genus *Deflandrea* Eisenack 1938

Deflandrea lata n.sp.

(Figure 1, A-C; holotype Figure 1A, F6621, paratype Figure 1C)

Occurrence. Gingin Brook silty limestone at 202-204 feet.

Description. Shell rather flat, without tabulation, broadly oval to nearly circular in outline, without a clearly defined girdle, occasionally a slight marginal indentation suggestive of a girdle has been present (Fig. 1A). Apex of shell with a small median and slightly concave

prominence; antapex narrower and more deeply concave than the apex with two short antapical horns.

Capsule widely separated from the wall of shell, nearly spherical to broadly oval in outline, its longer axis being at right angles to the longitudinal axis of the shell. Archeopyle small, intercalary in position, circular to oval in outline. Wall of both shell and capsule smooth and thin, that of the capsule being the thinner of the two.

Dimensions. Holotype—overall length 98 μ , overall width 84 μ , capsule c. 50 x 57 μ . Range—overall length c. 78-105 μ , overall width c. 76-97 μ ; capsule length c. 48-50 μ , width c. 48-75 μ .

Comment. Of the described species of *Deflandrea*, *D. lata* appears to come closest to *D. cretacea* Cookson 1956 originally described from three Upper Cretaceous deposits in the Nelson Bore, Victoria. It agrees with *D. cretacea* in the apparent absence of a girdle, but differs from this species in its rounded shape, the complete separation of the capsule from the shell and the greater prominence of the antapical projections.

Deflandrea cretacea Cookson 1956

(Figure 1D and E)

Deflandrea cretacea Cookson 1956, p. 104, Pl. 1, fig. 1-5.

Deflandrea cretacea Cookson; Cookson & Eisenack 1961, p. 71, Pl. 11, fig. 1, 2.

Deflandrea cretacea Cookson; Drugg 1967, p. 16, Pl. 2, fig. 17, 18.

Comment. The examples from the Gingin Brook silty limestone agree in general shape, form and type of ornamentation with those from the Victorian type locality, Nelson Bore at 6283, 6065 and 5304 feet. As in the latter, the degree of surface granulation varies considerably and in a few examples seems to be almost entirely absent (Fig. 1E).

The two examples referred to *D. cretacea* by Drugg (1967, Pl. 2, fig. 17, 18) differ from all the Australian examples of this species examined in the centralized position of the capsule. In this respect they are closer to the Western Australian species *D. lata* described above.

Deflandrea cf. verrucosa Manum 1963

(Figure 1F-H)

Deflandrea verrucosa Manum 1963, p. 60, Pl. 3, fig. 1-4.

Deflandrea verrucosa Manum; Manum & Cookson 1964, p. 9, Pl. 1, fig. 7.

Occurrence. Gingin Brook, Bore 4, 202-204 feet.

Comment. A few examples of the genus *Deflandrea* which approach *D. verrucosa* in the shape of the shell and the degree of coarseness and density of the ornament have been recovered from the Gingin Brook sample from Bore 4 at 202-204 feet. The resemblance to *D. verrucosa* is particularly evident in the specimen shown in Figure 1, F and G. In the second figured speci-

¹Botany Department, University of Melbourne

²University of Tübingen

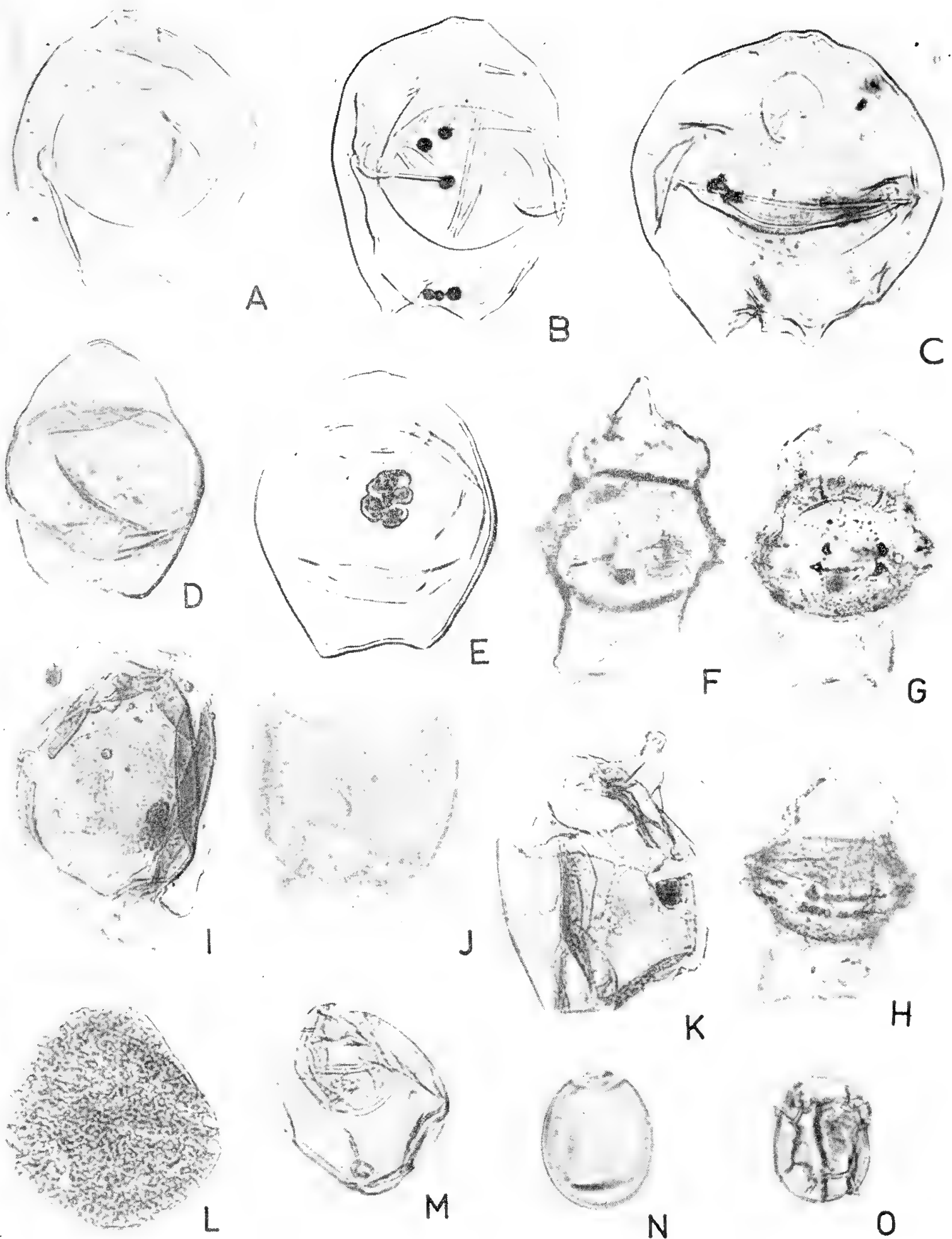


Figure 1. A, B, C.—*Deflandrea lata* n. sp. 1, ventral surface of holotype X c. 480, 2, 3, ventral surface of two other examples X c. 480. D, E.—*Deflandrea cretacea* Cookson & Eisenack X c. 650. F, G, H.—*Deflandrea* cf. *verrucosa* Manum X c. 480, 6, 7, ventral and dorsal views of the same example, 8, a second specimen X c. 480. I, J, K.—*Ascodinium lordi* n. sp. J, holotype X c. 480. I, K, two complete specimens X c. 480. *Apteodinium cribosum* n. sp. X c. 650. M.—*Disphaeria macropyla* Cookson & Eisenack X c. 480. N.—*Palaeostomocystis chytra* Drugg X c. 700.—*Gillinia hymenophora* Cookson & Eisenack X c. 700.

men (Figure 1H) the ornament is finer and in side view the "granules" are pointed. However, in the illustration of the holotype of *D. verrucosa* (Figure 3A) a few slightly pointed "warts" are evident.

The Western Australian examples are smaller than those from Graham Island, Arctic Canada, ranging from 100-120 μ in length and 64-67 μ in width, as against a range in length in *D. verrucosa* of 112-135 μ and width of 65-87 μ . In view of such differences we think a comparison with, rather than a definite reference to *D. verrucosa* is preferable until more examples become available.

Genus *Ascodinium* Cookson & Eisenack 1960

Ascodinium lordi n.sp.

(Figure 1, I-K, holotype Figure 1J F6624)

Occurrence. Gingin Brook silty limestone between 202-204 feet.

Description. Shell longer than broad with slightly convex sides and three well-defined horns. The apical as well as the two antapical horns are short, broadly-based and somewhat triangular in outline with convex sides and rounded apices.

The internal capsule is oval in shape and almost fills the shell laterally, but does not extend into the horns. In the equatorial region of the capsule a light, straight-sided strip, c. 4 μ wide, which extends to its lateral limits, has usually been evident in the stained specimens used in this investigation.

The wall of the shell is thin and more or less granular. The wall of the capsule is somewhat thicker and smooth, except near the margins where, in most specimens, a more or less coarse, somewhat finely reticulate pattern is evident (Fig. 1J). The shell opens by the detachment of the whole apex along a straight or zig-zag line (Fig. 1J) suggestive of tabulation.

Of the fair number of specimens seen the two illustrated were the only complete ones found.

Dimensions. Holotype—length c. 90 μ overall width of 77 μ , width of capsule c. 62 μ . Complete Paratypes overall length c. 106-120 μ , overall width 68-80 μ ; opened shell c. 74-95 μ long.

Comment. We are aware that in the original diagnosis of the genus *Ascodinium* it was stated that "the shells open by the detachment of a circular part of the apical region, including the apex itself and a part of the ventral wall". In order to avoid the establishment of a new genus for this particular Gingin Brook type we propose to enlarge the description of the genus *Ascodinium* as follows: The shell opens by the detachment of the apex along a circular, straight or zig-zag line. The specific name is given in honour of Mr. J. H. Lord, Director of the Geological Survey of Western Australia.

Family *APTEODINIACEAE* Eisenack

Genus *Apteodinium* Eisenack 1958

Apteodinium cribosum n.sp.

(Figure 1L, holotype Figure 1L F6623)

Occurrence. Gingin Brook, silty limestone between 202 and 204 feet.

Description. Shell pear-shaped, divided by an indistinct girdle into a rounded hypotheca and a narrower epitheca with a short, blunt apical horn. The girdle though indistinct is c. 6 μ wide.

The wall of the shell is relatively thick especially in the antapical region, and seems to be perforated by small, densely arranged pores which give it a coarsely granular appearance in spite of its relatively smooth surface.

Dimensions. Holotype—62 μ long, 53 μ wide; Paratype—85 μ long, 60 μ wide.

Family *PSEUDOCERATIACEAE* Eisenack

Genus *Odontochitina* Deflandre 1935

Odontochitina cribropoda Deflandre & Cookson 1955

(Figure 2, A-C)

Odontochitina cribropoda Deflandre & Cookson 1955 p. 292 Pl. 3, fig. 7-11.

Comment. Examples referable to *O. cribropoda*, previously recorded from Upper Cretaceous deposits at Gingin, W.A. and the Nelson Bore, Victoria at 5782 feet, which occur relatively frequently in the Gingin Brook silty limestone between 202 and 204 feet, show a rather high degree of variability. Except for one imperfectly presented complete example and a single detached apical horn, all have been represented by opened shells.

Constant features of the Gingin Brook examples are 1) the difference in length of the two antapical horns, 2) the presence in them of cylindrical unperforated proximal portions and somewhat broadened perforated distal portions, 3) the pointed character of the antapical horns. Variable characters are 1) the degree of divergence of the antapical horns from nearly parallel to widely divergent, 2) the proportion of the perforated to the unperforated portions, 3) the breadth of the perforated to that of the unperforated parts, which is usually cylindrical and 4) the density and coarseness of the perforation.

Dimensions. Apical horn (complete) 158 μ long, antapical horns 52-162 μ long.

Odontochitina sp.

(Figure 2D, F6624)

Comment. A form which apparently represents a new species of *Odontochitina* has occurred regularly in the preparations of Gingin Brook silty limestone between 202 and 204 feet. Twelve specimens have been mounted and examined but, since none of them has been complete, we are refraining from raising this form to specific rank.

The two main features which distinguish this form from *O. cribropoda* Deflandre & Cookson 1955, with which it is associated, are 1) the antapical horns which are inserted at the corners of the hypotheca are long, widely divergent, thick walled and sometimes striated, and 2) the perforation of the thin-walled portions is restricted to the extreme ends of the horns and is frequently partially or completely missing.

Dimensions. Maximum length of horns 147 μ .

Family *HYSTRICHOSPHERACEAE* O. Wetzel emend Evitt

Genus *Hystrichosphaera* O. Wetzel 1933 emend. Deflandre 1937

Hystrichosphaera cf. *wetzelii* Deflandre 1937 (Figure 2E-F)

Hystrichosphaera wetzelii Deflandre 1937, p. 65, Pl. 11, fig. 8.

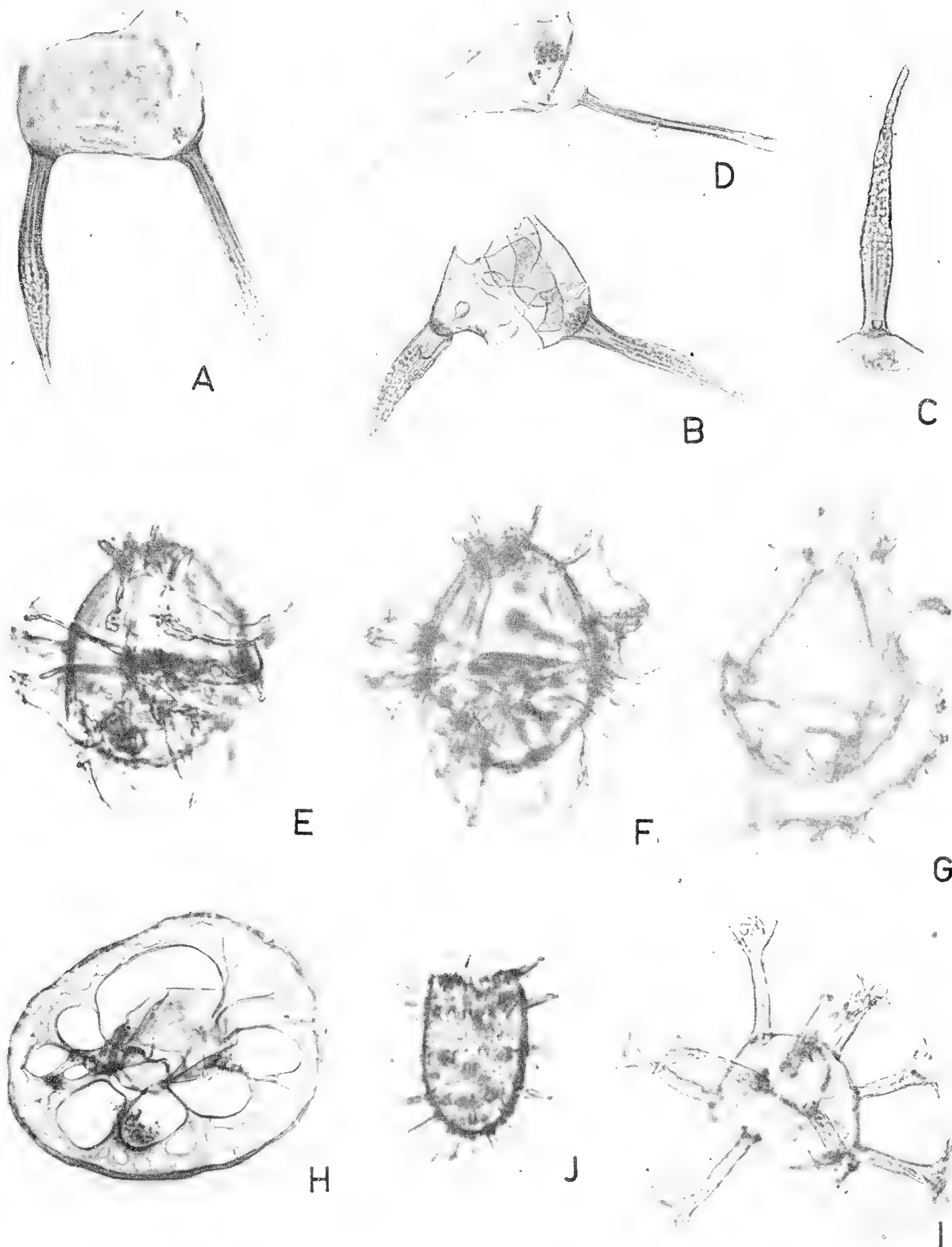


Figure 2. A, B, C.—*Odontochitina cribropoda* Deflandre & Cookson 1, 2, hypotheca of two examples 1, X c. 330, 2, X c. 260, 3, portion of epitheca with apical horn X c. 260. D.—*Odontochitina* sp. hypotheca X c. 260. E, F.—*Hystrichosphaera* cf. *Wetzelii* Deflandre, dorsal and ventral surface X c. 700. G.—*Hystrichosphaera paradoxa* n. sp. side view X c. 670. H.—*Aiora fenestrata* (Deflandre & Cookson) X c. 470. I.—*Tanyosphaeridium isocalamus* (Deflandre & Cookson) X c. 650 J.—*Oligosphaeridium* sp. X c. 340.

Comment. The single specimen obtained from the Gingin Brook silty limestone between 202 and 204 feet herein compared with *Hystrichosphaera wetzeli* Deflandre has, like this species, a tabulation close to that of *H. furcata* (Ehrenberg) and *H. ramosa* (Ehrenberg). However, it is distinct from both of these species in that, as in *H. wetzeli*, its fields are bounded by relatively high membranes with concave edges.

The Gingin Brook specimen, lying as it does in a dorsoventral position, shows both the ventral fields and the archeopyle on the dorsal surface. The membrane outlining the fields are somewhat lower than those of *H. wetzeli*. Unfortunately the exact tabulation of the ventral surface of the holotype of *H. wetzeli* is not fully known so that a definite connection between this species and the Gingin Brook specimen cannot, at present, be established.

Dimensions. Overall length 70 μ ; overall width 57 μ ; central body 48 μ long, 38 μ wide; borders of fields 10-15 μ high.

Hystrichosphaera paradoxa n. sp.
(holotype Figure 2G, F6625; Figure 3)

Description. The single example recovered from the Gingin Brook silty limestone between 202 and 204 feet is lying sideways on. In this position it is somewhat pear-shaped in that the antapical portion is more rounded than the apical. The apex of the central body bears a small cylindrical prominence, while its surface

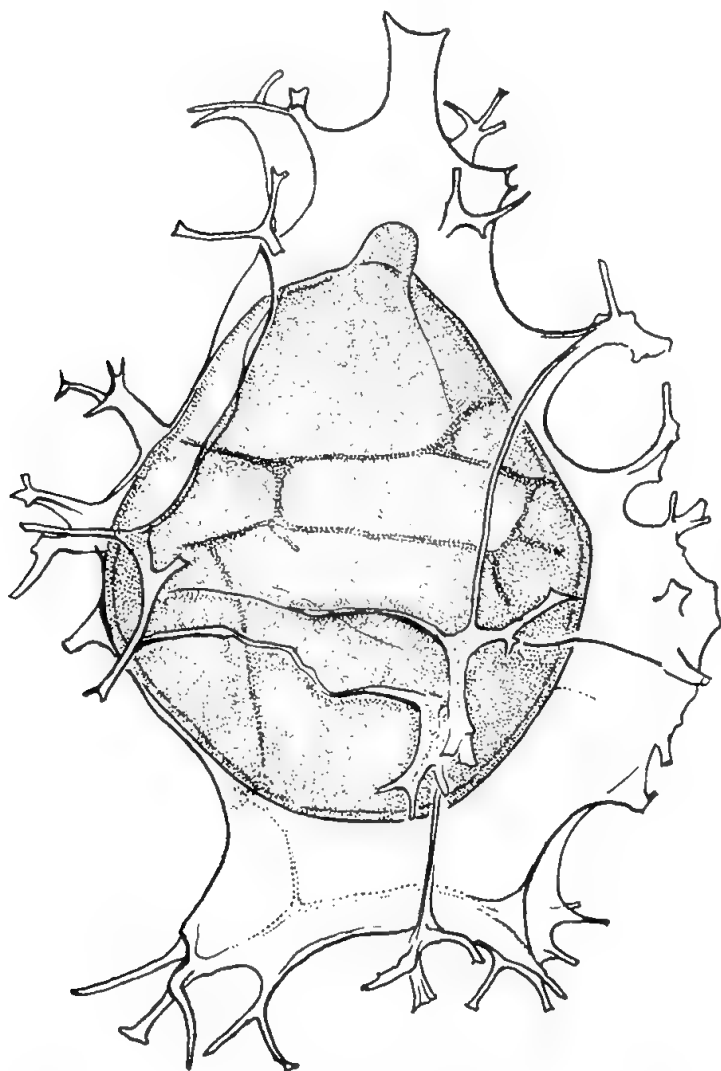


Figure 3.—*Hystrichosphaera paradoxa* n.sp. (x1053).

supports a system of ledges which approximates in arrangement to those of *Hystrichosphaera furcata* (Ehrenberg) and *H. ramosa* (Ehrenberg). A girdle divided into fields is evident. In the apical region high membranous ledges form a hollow "cap" which surmounts the apex of the central body and ends in a short median projection bearing short, slightly forked appendages at about half its length. Similar appendages are also present at the corners of the fields and on the ledges, for example of the girdle and at the basal parts of the archeopyle which is recognisable on the left hand side of the specimen.

On the side opposite to the archeopyle and commencing just above the girdle there is a system of membranes which extends downwards forming a wide outgrowth, the edges of which also bear short forked appendages. Both the apical and antapical outgrowths seem to be six-sided; the dorsal side (left hand) appears to have no such membranes.

Dimensions. Central body 50 x 42 μ ; overall 94 x 64 μ .

Family *HYSTRICHOSPHAERIDIACEAE* Evitt
Genus *Oligosphaeridium* Davey & Williams 1966
Oligosphaeridium pulcherrimum (Deflandre & Cookson 1955)

(Figure 4E)

Hystrichosphaeridium pulcherrimum Deflandre & Cookson 1955, p. 270, Pl. 1, fig. 8, text fig. 21.

Hystrichosphaeridium pulcherrimum Deflandre & Cookson; Valensi 1955, p. 592, Pl. 4, fig. 1.

Oligosphaeridium pulcherrimum (Deflandre & Cookson) Davey & Williams 1966, p. 75, Pl. 11, fig. 5.

Comment. The specimen from the Gingin Brook silty limestone between 202 and 204 feet agrees in all characters with the holotype from a Lower Cretaceous deposit at Onepah, New South Wales.

Oligosphaeridium sp.

(Figure 2I, F6626)

Occurrence. Gingin Brook Bore 4, silty limestone between 202-204 feet.

Description. The single, well characterized though incomplete specimen recovered seems referable to the genus *Oligosphaeridium*. It has a smooth, apparently single-layered wall and ten long, tubular appendages with funnel-shaped ends, the edges of which are fringed with finely branched fibrils. The surface of the appendages is ornamented with small thickenings which tend to be arranged in longitudinal rows.

Dimensions. Shell—diameter c. 68 μ ; appendages c. 56 μ long; overall diameter c. 170 μ .

Genus *Tanyosphaeridium* Davey & Williams 1966
Tanyosphaeridium isocalamus (Deflandre & Cookson 1955)

(Figure 2J)

Hystrichosphaeridium isocalamus Deflandre & Cookson 1955, p. 272, Pl. 2, fig. 7, 8, Fig. 30-35.

Comment. The single specimen recovered from the Gingin Brook silty limestone between 202 and 204 feet agrees closely with the type from a ?Lower Cretaceous deposit at Onepah Station, New South Wales. Its surface is densely granular and the apices of the appen-

dages sharply truncate, in contrast to those of *T. variecalamum* Davey & Williams (1966) from the Upper Cretaceous (Cenomanian) England.

Genus *Anthosphaeridium* n. gen.

Description. Shell typically spherical, completely covered with short, densely arranged, striated, funnel-shaped appendages.

Type species: *Anthosphaeridium convolvuloides* n. sp.

Anthosphaeridium convolvuloides n. sp.

(Figure 4A-D; holotype Figure 4A, F6627)

Occurrence. Gingin Brook No. 4 Borehole, silty limestone between 202-204 feet.

Description. Shell small, circular in outline with a thin, finely granular wall. Appendages very numerous, apparently hollow throughout their length, consisting of a short, gradually widening tubular stalk and a widely open funnel-shaped terminal portion, the wall of which is longitudinally striated (Fig. 4B-D). The appendages resemble the flowers of *Convolvulus* sp. in shape, hence the choice of the specific name.

Dimensions. Holotype—shell c. 44 μ ; overall diameter c. 70 μ . Range—shell c. 40-50 μ , overall diameter c. 56-80 μ .

Comment. *A. convolvuloides* is a readily recognisable type in spite of the fact that, owing to the thinness of the wall, it is liable to distortion as the result of the treatment received.

Genus *Heterosphaeridium* n. gen.

Description. Shell circular in outline with numerous solid appendages of varying widths in one and the same specimen and opening by the removal of the whole apex along a straight line.

Type species: *Heterosphaeridium conjunctum* n. sp.

Heterosphaeridium conjunctum n. sp.

(Figure 4G-H; holotype Figure 4H, F6628)

Occurrence. Gingin Brook No. 4 Borehole, silty limestone between 202 and 204 feet.

Description. Shell circular in outline, wall covered with numerous simple or variously divided appendages of equal length but very variable width, which narrow distally from slightly broadened bases. The apices of the appendages are either simple, branched or fringed, and their bases are frequently joined by relatively broad surface ridges which delimit relatively large polygonal areas. The shell opens by the detachment of the whole apex along a straight line. The wall of the shell is finely and densely granular.

Dimensions. Holotype—shell c. 114 μ long and c. 128 μ broad; overall c. 133 μ x c. 157 μ . Range—width of shell c. 70 μ —133 μ , overall width c. 125 μ —c. 170 μ .

Family Uncertain

Genus *Gillinia* Cookson & Eisenack 1960

Gillinia hymenophora Cookson & Eisenack 1960

(Figure 1, O)

Gillinia hymenophora Cookson & Eisenack 1960, pp. 11, 12, Pl. 3, fig. 4-6.

Comment. This readily recognizable form has appeared regularly in preparations of the portion of the Gingin Brook silty limestone

examined. The specimens agree exactly with those from the Western Australian Upper Cretaceous (Upper Turonian to Upper Senonian) localities listed in the original description.

Group *ACRITARCHA* Evitt 1963

Subgroup *DISPHAEROMORPHITAE*

Genus *Disphaeria* Cookson & Eisenack 1960

Disphaeria macropyla Cookson & Eisenack 1960

(Figure 1M)

Disphaeria macropyla Cookson & Eisenack 1960, p. 11, Pl. 3, fig. 13, 14.

Comment. Several examples which agree with *D. macropyla*, originally described from the Turonian Gearle Siltstone, Rough Range Bore 1 and from the Molecap Greensand Western Australia, have been recovered from the Gingin Brook silty limestone between 202 and 204 feet.

Subgroup Uncertain

Genus *Aiora* Cookson & Eisenack

Aiora fenestrata (Deflandre & Cookson 1955)

(Figure 2H)

Cannosphaeropsis fenestrata Deflandre & Cookson 1955, p. 283, Pl. 3, fig. 2.

Aiora fenestrata (Deflandre & Cookson) Cookson & Eisenack 1960, p. 9, Pl. 5, fig. 17, 18.

Aiora fenestrata (Deflandre & Cookson) Wilson 1967, p. 69, fig. 2c, 37, 38.

Comment. Several well preserved examples of *A. fenestrata* have been recovered from the Gingin Brook silty limestone between 202 and 204 feet. In one of these a faint suggestion of the archcypyle demonstrated by Wilson 1967 as occurring in Antarctic Lower Tertiary examples was observed, but not clearly enough for exact comparison and photographic illustration. Otherwise the Gingin Brook examples have been well preserved and in close agreement with those recorded from Upper Cretaceous deposits in the Gingin area (Molecap Greensand) and Rough Range South No. 1 bore between 2500-2511 ft. in Western Australia.

Genus *Palaeostomocystis* Deflandre

Palaeostomocystis chytra Drugg

(Figure 1N)

Palaeostomocystis chytra Drugg 1967, p. 35, Pl. 6, fig. 12.

Comment. Specimens which agree closely with *P. chytra* are relatively numerous in the Gingin Brook silty limestone between 202 and 204 feet. They agree in shape and size with those from the Upper Moreno Formation of California. They are oval in shape with a smooth surface and concave opening. The "lid" often attached, as in the figured example, is considerably smaller than the subsequent opening.

Dimensions. Figured specimen c. 32 x 25 μ , opening c. 12 μ .

II. Gingin Brook No. 4 Borehole, core 2 between 404 and 414 feet

The glauconitic carbonaceous claystone at the above depth has a rich microplankton content which differs completely from that of the above described silty limestone of core 2 at 202 to 204 feet. No attempt has been made to identify all the forms present. However, enough of them have been studied to indicate that the age of

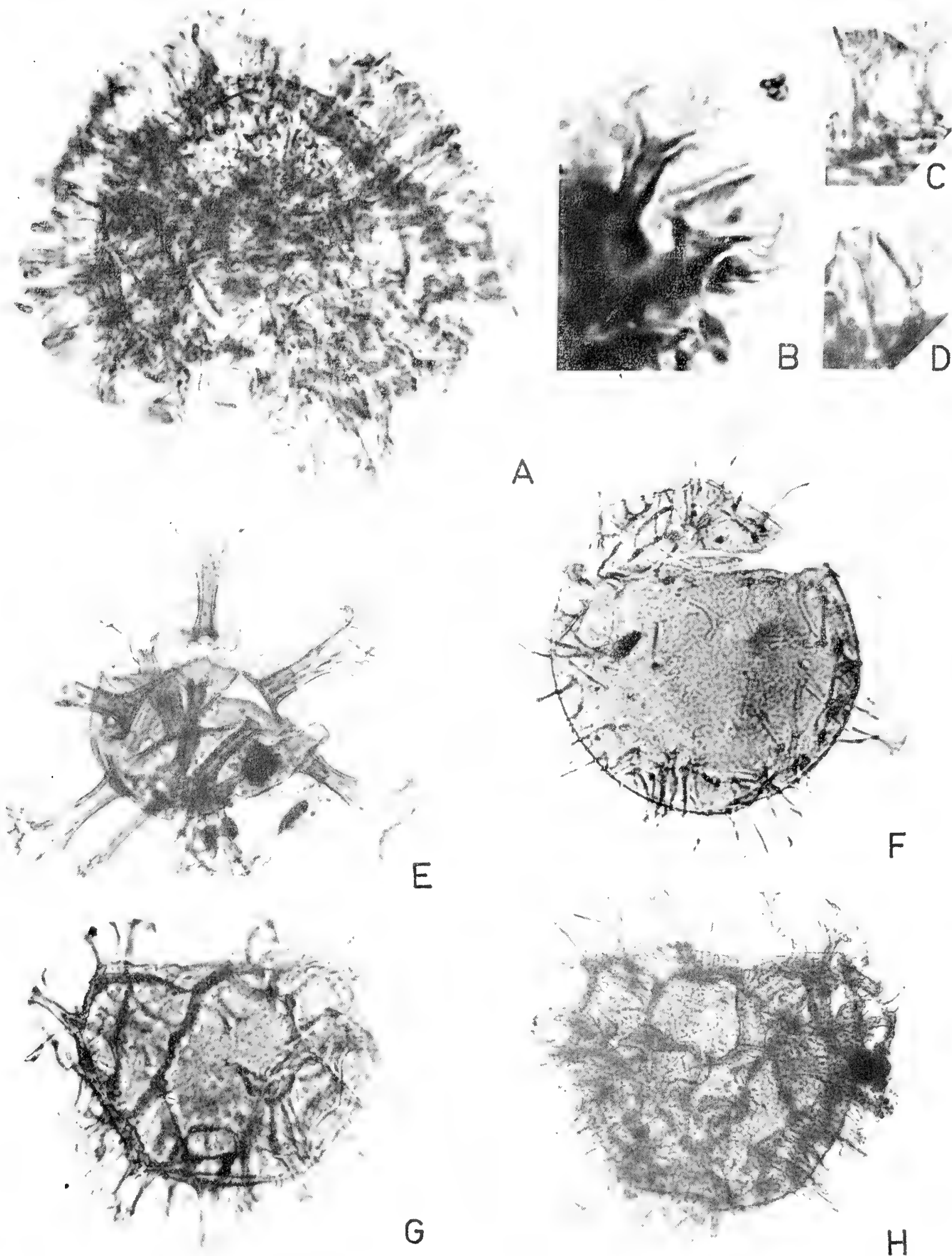


Figure 4. A, B, C, D.—*Anthosphaeridium convolvuloides* n. sp. 1, holotype X c. 1140, 2-4, appendages showing longitudinal striations, 2 X c. 1800, 3, 4 X c. 1400. E.—*Oligosphaeridium pulcherrimum* (Deflandre & Cookson) X c. 470. F.—*Cyclonephelium distinctum* Cookson & Eisenack X c. 500. G, H.—*Heterosphaeridium conjunctum* n. sp. 19, paratype X c. 500, 8, holotype X c. 500.

the deposit as a whole approximates to Mid-Cretaceous. (B. Ingram in Sanders 1966.)

Dinoflagellata

Family GONYAULACACEAE Lindemann

Genus *Gonyaulacysta* Deflandre 1964

Gonyaulacysta edwardsi (Cookson & Eisenack)

(Figure 5A and B)

Gonyaulax edwardsi Cookson & Eisenack 1958, p. 32, Pl. 3, fig. 45, fig. 7.

Gonyaulax edwardsi Cookson & Eisenack; Cookson & Hughes 1964, p. 43, Pl. 5, fig. 9.

Comment. *Gonyaulacysta edwardsi* has occurred in relatively large numbers in the preparation of the Gingin Brook No. 4 bore, core 2 at 404-414 feet. It was originally recorded from a number of Western Australian Cretaceous deposits, the age of which ranges from Albian, for example Seismic shot holes B2 at 230 feet and L8 at Gingin, to Cenomanian to Lower Turonian in the Gearle Siltstone (upper part), Wapet's Rough Range Well, 5 at 1570 feet. It was not found in any of the preparations of the Gingin Brook silty limestone core 1, 202-204 feet.

G. edwardsi has also been recorded from Albian to Mid-Cretaceous deposits near Cambridge, England (Cookson & Hughes 1964).

Gonyaulacysta cassidata (Eisenack & Cookson)

(Figure 5C)

Gonyaulax helicoides subspecies *cassidata* Eisenack & Cookson 1960, p. 3, Pl. 1, fig. 5, 6.

Gonyaulax cassidata Eisenack & Cookson; Cookson & Eisenack 1962, Pl. 2, fig. 11, 12.

Gonyaulax cassidata Eisenack & Cookson; Cookson & Hughes 1964, p. 42, Pl. 5, fig. 10, 11.

Comment. The figured specimen was recovered from the Gingin Brook No. 4 bore at 404-414 feet. It has all the characters of the type and subsequent examples recorded from Australian Aptian—Cenomanian deposits (Cookson & Eisenack 1962). *G. cassidata* has also been recorded from Mid-Cretaceous beds, near Cambridge, England (Cookson & Hughes 1964). Sargeant (1966) regards one of the two Cambridge specimens (Pl. 5, fig. 11) as a representative of *Psaligonyaulax deflandrei* Sargeant.

Family DEFLANDREACEAE Eisenack

Genus *Scriniodinium* Klement 1957

Scriniodinium galeatum Cookson & Eisenack

1960

(Figure 5D)

Scriniodinium galeatum Cookson & Eisenack 1960, p. 3, Pl. 1, fig. 16-18.

Comment. Several specimens of *S. galeatum* have been recovered from the Gingin Brook bore 4, core 2, 404-414 feet. They agree in general features with those previously recorded from the Albian to Cenomanian Lower Gearle Siltstone, Rough Range South No. 1 bore, core 69 (2748-2758 feet). Upper Albian to Cenomanian deposit north of Gingin, Wapet's seismic shot hole B1, at 210 feet, and the Brickhouse Bore at 1210 feet, probably Cenomanian.

Genus *Ascodinium* Cookson & Eisenack 1960

Ascodinium acrophorum Cookson & Eisenack 1960

(Figure 5K)

Deflandrea acuminata Cookson & Eisenack 1958, p. 27, Pl. 4, fig. 8.

Ascodinium acrophorum Cookson & Eisenack 1960, p. 5, Pl. 1, fig. 19, 20.

Comment. Specimens of this species which agree with those from the ?Upper Albian to to Cenomanian Osborne Formation, Subiaco Bore, Western Australia at 358 feet and the Fremantle Traffic Bridge bore 5, at 100 feet, have occurred occasionally in the Gingin Brook sample from Bore 4, core 2 at 404-414 feet.

Ascodinium parvum (Cookson & Eisenack 1958)

(Figure 5J)

Deflandrea parva Cookson & Eisenack 1958, p. 28, Pl. 4, fig. 12.

Ascodinium parvum (Cookson & Eisenack); Cookson & Eisenack 1960, p. 5, Pl. 1, fig. 23-25.

Comment. *A. parvum*, which has been recorded from a relatively large number of Western Australian Albian to Cenomanian deposits (Cookson & Eisenack 1960), has occurred in small numbers in the Gingin Brook No. 4 sample from core 2, at 404-414 feet.

Family PSEUDOCERATIACEAE Eisenack

Genus *Pseudoceratium* Gocht 1957

Pseudoceratium ludbrookii (Cookson & Eisenack 1958)

(Figure 5E)

Ceratocystidicopsis ludbrookii Cookson & Eisenack 1958, p. 52 Pl. 5, fig. 7, 8.

Pseudoceratium ludbrookii (Cookson & Eisenack); Eisenack 1961, p. 299.

Comment. *P. ludbrookii* has been recorded from several deposits in Western Australia, and one from South Australia, all of which are believed to be of Albian age. Several examples have been recovered from the Gingin Brook sample from Bore 4, core 2, between 404 and 414 feet, but in all the apical portion of the shell has been missing.

Family APTEODINIACEAE Eisenack

Genus *Apteodinium* Eisenack 1958

Apteodinium maculatum Eisenack & Cookson 1960

(Figure 5F)

Apteodinium maculatum Eisenack & Cookson 1960, p. 4, Pl. 2, fig. 1-3.

Comment. *Apteodinium maculatum*, readily recognizable by the groups of circular thickenings that occur on the surface of the archeopyle and other areas, has occurred in the Gingin Brook sample from Bore 4 between 404 and 414 feet. *A. maculatum* was originally recorded from the Aptian Roma Formation, North Queensland, Batavia Downs Well between 45-49 feet, and Albian deposits such as the Lower Gearle Siltstone in Western Australia, Rough Range Bore No. 7 at 2,360-2,375 feet, and in the Santos Oodnadatta Bore, South Australia at 87-327 feet.

Family GYMNODINIACEAE Lemmermann

Genus *Diconodinium* Eisenack & Cookson 1960

Diconodinium dispersum (Cookson & Eisenack 1958)

(Figure 5H)

Palaeohystrichophora dispersa Cookson & Eisenack 1958, p. 39, Pl. 10, fig. 12, 14.

Diconodinium dispersum (Cookson & Eisenack) Eisenack & Cookson, 1960, p. 3.

Comment. *D. dispersum* was originally described from two deposits, one near Gingin, W.A. from Seismic Shot Hole B2 at 230 feet, the

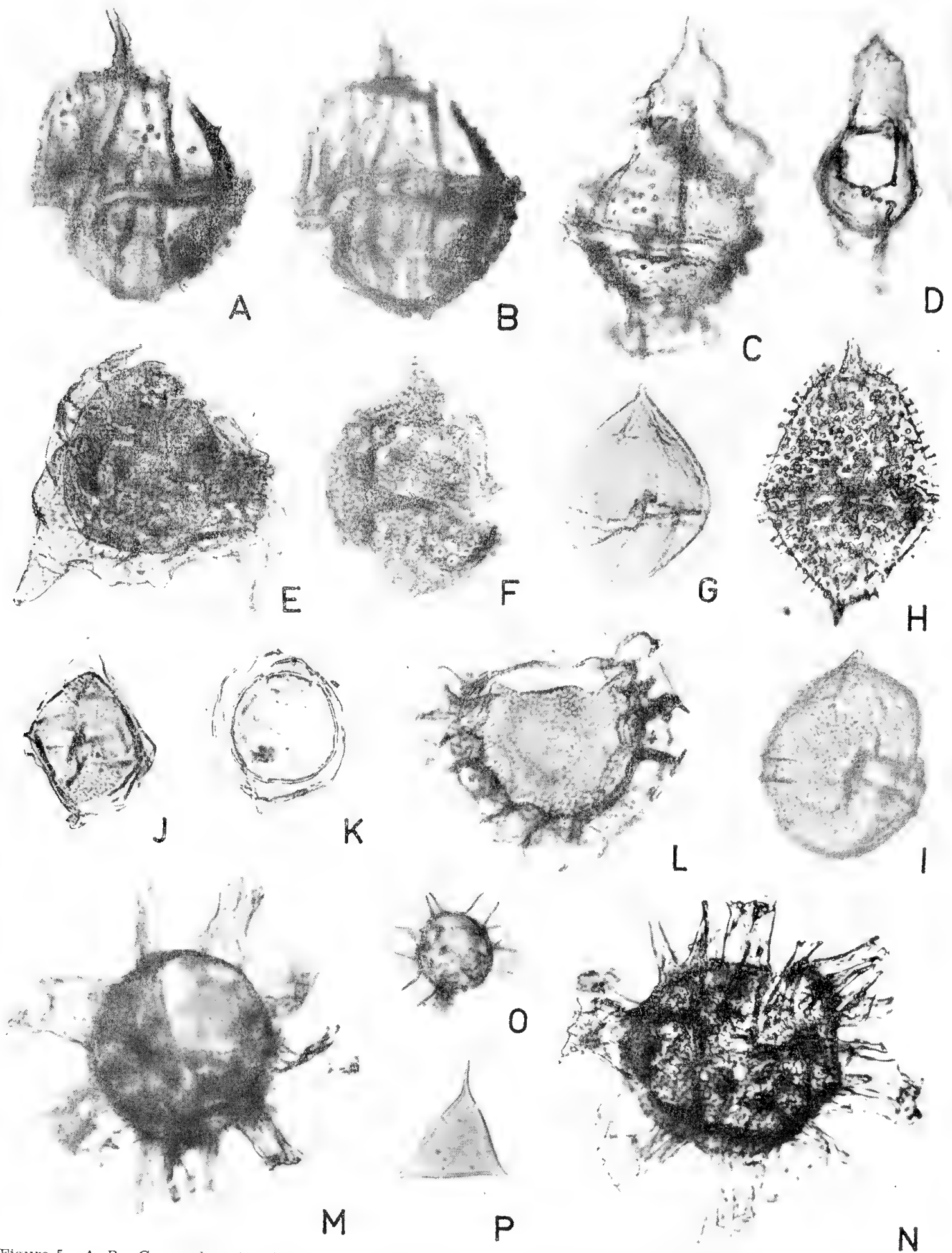


Figure 5. A, B.—*Gonyaulacysta edwardsi* (Cookson & Eisenack) dorsal and ventral surfaces X c. 300. C.—*Gonyaulacysta cassidata* (Cookson & Eisenack) X c. 680. D.—*Scriniodinium galeatum* Cookson & Eisenack X c. 430. E.—*Pseudoceratium ludbrookii* Cookson & Eisenack X c. 330. F.—*Apteodinium glabrum* Eisenack & Cookson X c. 470. G.—*Apteodinium maculatum* Eisenack & Cookson X c. 470. H.—*Diconodinium inflatum* Eisenack & Cookson X c. 470. I.—*Diconodinium dispersum* Cookson & Eisenack X c. 300. J.—*Ascodinium acrophorum* Cookson & Eisenack X c. 300. K.—*Ascodinium parvum* Cookson & Eisenack X c. 300. L.—*Cyclonephelium acrophorum* Cookson & Eisenack X c. 300. M, N.—*Cordosphaeridium chimaera* n. sp. X c. 470. O.—*Lithosphaeridium siphoniphorum* (Cookson & Eisenack) X c. 400. P. *Veryhachium reductum* Deunff X c. 700.

other from King Edward Street Bore, near Perth, W.A. between 265 and 925 feet, both of which are believed to be of Albian age. Later, Eisenack and Cookson (1960) recorded a third occurrence, namely from the Subiaco Bore, W.A. at 358 feet. The examples from the Gingin Brook No. 4 Borehole between 404 and 414 feet agree completely with the earlier examples.

Diconodinium glabrum Eisenack & Cookson
1960

(Figure 5G)

Diconodinium glabrum Eisenack & Cookson
1960, p. 3, Pl. 1, fig. 11.

Comment. Examples which agree with *D. glabrum*, originally recorded from Albian deposits in the Gingin area (Moora Bore 86-170 feet), the Lower Gearle Siltstone, Wapet's Rough Range Bore No. 7 at 2360-2375 feet, and the Santos Oodnadatta Bore, S.A. at 237 and 367 feet, have been recovered from the Gingin Brook sample between 404-414 feet.

Diconodinium inflatum Eisenack & Cookson
1960

(Figure 5I)

Diconodinium inflatum Eisenack & Cookson
1960, p. 4, Pl. 1, fig. 12, 13.

Comment. A few specimens have been recovered from the Gingin Brook borehole at 404-414 feet which agree in general form and structure with those from the ?Upper Albian to Cenomanian sample from Wapet's Seismic Shot Hole B1 at 220 feet, north of Gingin, W.A.

Family Uncertain

Genus *Canninginopsis* Cookson & Eisenack 1962
Canninginopsis denticulata Cookson & Eisenack
1962

Canninginopsis denticulata Cookson & Eisenack
1962, p. 488, Pl. 1, fig. 16-19.

Comment. *C. denticulata*, a widespread Mid-Cretaceous Western Australian type, occurs in the Gingin Brook Bore 4, core 2, between 404 and 414 feet. The specimens were rather crumpled and not suitable for illustration.

Family HYSTRICHOSPHAERIDIACEAE Evitt

Genus *Hystrichosphaeridium* Deflandre 1937

Hystrichosphaeridium stellatum Maier 1959
(Figure 6J)

Hystrichosphaeridium stellatum Maier 1959, p. 320, fig. 3, 4.

Hystrichosphaeridium stellatum Maier; Cookson & Eisenack 1962, p. 492, Pl. 4, fig. 14.

Hystrichosphaeridium stellatum Maier; Cookson & Hughes 1964, p. 48, Pl. 9, fig. 11.

Hystrichosphaeridium stellatum Maier; Manum & Cookson 1964, p. 4, Pl. 3, fig. 4.

Hystrichosphaeridium stellatum Maier; Drugg 1967, p. 27, Pl. 4, fig. 11.

Comment. The single specimen of this type recovered from the Gingin Brook No. 4 Borehole deposit between 404 and 414 feet agrees closely with those recorded by Cookson and Eisenack (1962) from a number of Western Australian Albian deposits, including one from a bore core from the neighbourhood of Gingin. It also agrees with the specimen figured by Cookson and Hughes (1964) from the Mid-Cretaceous Cambridge Greensand and the one figured by Drugg (1967) from the Danian of

California. Whether or not the Cretaceous examples are specifically distinct from Maier's Tertiary form only future work will decide.

Hystrichosphaeridium ferox Deflandre 1937

(Figure 6K)

Hystrichosphaeridium ferox Deflandre 1937, p. 72, Pl. 14, fig. 3, 4.

Hystrichosphaeridium ferox Deflandre; W. Wetzel 1952, p. 402, Pl. A, fig. 13, fig. 20.

Hystrichosphaeridium ferox Deflandre; Eisenack; 1958, p. 401, Pl. 27, fig. 1, 2.

Hystrichosphaeridium ferox Deflandre; Gocht 1959, p. 71, Pl. 4, fig. 1.

Baltisphaeridium ferox (Deflandre) Downie & Sargeant 1963, p. 89-92.

Non *Baltisphaeridium ferox* (Deflandre) Cookson & Hughes 1964, p. 55, Pl. 10, fig. 11.

Occurrence. Gingin Brook Bore No. 4, 404-414 feet.

Comment. Specimens which, although somewhat larger, agree closely with the example described and figured by Deflandre (1937) under the name *Hystrichosphaeridium ferox* have occurred in the Gingin Bore sample.

Recently, with the permission of Professor Deflandre, it has been suggested that this species be transferred to the genus *Hystrichokolpoma* Klumpp (Williams and Downie 1966, p. 181). Since, in the original description of *Hystrichokolpoma*, the presence of a distinctly larger antapical process was specified, a feature absent from the type of *H. ferox* and our Australian representatives, we are leaving the question open and using the original designation.

Genus *Lithosphaeridium* Davey & Williams 1966

Lithosphaeridium siphoniphorum (Cookson & Eisenack)

(Figure 5, O)

Hystrichosphaeridium siphoniphorum Cookson & Eisenack 1958, p. 44, Pl. 11, fig. 10.

Hystrichokolpoma sp. A. Baltes 1963, p. 587, Pl. 6, fig. 1-5.

Hystrichokolpoma sp. B. Baltes 1963, p. 587, Pl. 6, fig. 6-8.

Hystrichosphaeridium siphoniphorum Cookson & Eisenack; Cookson & Hughes 1964 p. 48, Pl. 9, fig. 15.

Lithosphaeridium siphoniphorum (Cookson & Eisenack); Davey & Williams 1966, p. 79, Pl. 7, fig. 7, 8.

Comment. *L. siphoniphorum* has been recorded from a considerable number of ?Cenomanian to Albian deposits in Western Australia. The specimen figured herein, from the Gingin Brook Bore 4 between 404 and 414 feet, agrees closely with the one from the Gingin area (Seismic Shot Hole B2 at 230 feet) originally illustrated by Cookson and Eisenack 1958, Pl. 11, fig. 10. The surface of the Australian specimens is finely and closely granular, not reticulate as in the British examples (Davey & Williams 1966, p. 80).

Dimensions. Shell 28-40 μ in diameter, overall diameter 47-76 μ .

Genus *Cleistosphaeridium* Davey, Downie, Sarjeant and Williams 1966

Cleistosphaeridium ancoriferum (Cookson & Eisenack) emend.

(Figure 6 A-G)

Hystrichosphaeridium ancoriferum Cookson & Eisenack 1960, p. 8, Pl. 2, fig. 11.

Hystriosphæridium ancoriferum Cookson & Eisenack; Cookson & Hughes 1964, p. 4, Pl. 9, fig. 7.

Cleistosphæridium ancoriferum (Cookson & Eisenack); Davey, Downie, Sargeant & Williams 1966, p. 167, Pl. 6, fig. 5, Pl. 9, fig. 1.

Age and Occurrence. *C. ancoriferum* was earlier recorded from a number of Western Australian Albian-Cenomanian deposits. These include the lower part of the Gearle Siltstone, Rough Range South Bore 1 at 2748-2758 feet, Wapet's Seismic Shot Hole B1 at 210 and 220 feet north of Gingin and the Osborne Formation in the Perth area.

Comment. Specimens referable to *C. ancoriferum* are not uncommon in the sample from Gingin Brook between 404 and 414 feet. Such examples are particularly well-preserved and under an oil immersion lens have shown details regarding the structure not noticed during our original investigation of this form. The occurrence of these new features led to a re-examination of the holotype of *C. ancoriferum* (Fig. 6B) with the result that the emended description which follows, based on the original holotype and the new specimens from the Gingin Brook deposit, is now necessary.

Emended Description. Shell spherical, relatively small, with numerous (more than 50) relatively short, somewhat broadly-based appendages which are almost straight sided or slightly narrowed distally. The appendages are hollow, distinctly septate with a surface ornament of minute, irregular or dot-like projections (Fig. 6, C and G); at the apex of each appendage a slight widening results in a somewhat V-shaped appearance (Fig. 6G) and the whole apex is enveloped in a thin, smooth, roughly circular "cap", the edges of which curve slightly backwards towards the shell (Fig. 6C, G). The enlarged apices are quite often in direct contact with one another, while others are free (Fig. 6D, F). Whether the former is the natural position and the apices are connected by a continuous membrane, or whether their frequent apparent freedom results from the chemical treatment to which the shells have been subjected, it is impossible to tell. Certain it is that no membrane similar to that present in the genus *Chlamydophorella* (Fig. 6H) is represented in *C. ancoriferum*.

Dimensions. Holotype (Fig. 6B) overall diameter c. 70 μ , shell c. 52 μ ; figured specimen (Fig. 6A) overall diameter c. 60 μ , shell c. 42 μ .

Comment. As far as can be judged from the illustrations given by Davey, Downie, Sargeant and Williams (Pl. 6, fig. 5; Pl. 9, fig. 1), the specimens from the Fletcham Hill Borehole, Surrey, England appear to have little in common with the Australian species. So far an archeopyle has not been evident in the many Australian examples observed.

Family CYCLONEPHELIACEAE Eisenack

Genus *Cyclonephelium* Deflandre & Cookson 1955
emend Cookson & Eisenack 1962 and Williams and Downie 1966

Cyclonephelium distinctum Deflandre & Cookson (Figure AF)

Cyclonephelium distinctum Deflandre & Cookson 1955, p. 285 Pl. 2, fig. 14.

Cyclonephelium distinctum Deflandre & Cookson; Gocht 1958 vol. 3, p. 77, Pl. 4, figs. 16-18.

Circulcdinium deflandrei Alberti 1961, p. 293, Pl. 4, figs. 7-13.

Cyclonephelium distinctum Deflandre & Cookson; Cookson & Eisenack 1962, p. 495, Pl. 4, fig. 11.

Comment. *C. distinctum* has already been recorded (Cookson & Eisenack 1962) from a relatively large number of Western Australian deposits, which range in age from Albian (Lower Gearle Siltstone, Wapet's Rough Range South Bore No. 1 between 2860 and 2867 feet) to probably Turonian and Mid-Senonian (north of Gingin, Wapet's Seismic Shot Hole B1 at 160 feet. *C. distinctum* has occurred frequently in preparations of the silty limestone Gingin Brook Bore 4 between 404 and 414 feet.

Cyclonephelium membraniphorum Cookson & Eisenack 1962

(Figure 5L)

Cyclonephelium compactum Deflandre & Cookson 1955; Cookson & Eisenack 1958, p. 48, Pl. 12, fig. 8.

Cyclonephelium membraniphorum Cookson & Eisenack 1962, Pl. 6, fig. 8-14.

Comment. Examples resembling those of *C. membraniphorum* from a large number of Albian to ?Cenomanian deposits in Western Australia, including one from the Gingin area, Wapet's Seismic Shot Hole B1 at 200-210 feet (Cookson & Eisenack 1962, p. 495) have been recovered from the Gingin Brook No. 4 Borehole, between 404 and 414 feet.

Family Uncertain

Genus *Coronifera* Cookson & Eisenack 1958

Coronifera oceanica Cookson & Eisenack 1958

(Figure 6K)

Coronifera oceanica Cookson & Eisenack 1958, p. 45, Pl. 12, fig. 5, 6.

Coronifera oceanica Cookson & Eisenack; Cookson & Hughes 1964, p. 56, Pl. 9, fig. 8, 9.

Comment. Only one example of *C. oceanica* has so far been recovered from the Gingin Brook Bore 4, between 404 and 414 feet. It is of special interest since it is the only one so far found in which an archeopyle has been developed and the orientation of the shell determinable. Although this example is somewhat obliquely presented, there is little doubt that the archeopyle is apical and the single large tubular horn, characteristic of the genus *Coronifera*, antapical.

This specimen is densely covered with rather long, flexible, hair-like appendages. It is closer in general features to the examples from the Cambridge Greensand than to the holotype, in which a stiff spine was recorded as present at the end opposite the horn.

Dimensions. Shell c. 58 μ long and c. 52 μ broad; overall length c. 95 μ , overall breadth c. 94 μ , antapical horn c. 24 μ long, appendages c. 14-16 μ long.

Genus *Hexagonifera* Cookson & Eisenack 1961
Hexagonifera chlamydata Cookson & Eisenack 1962

Hexagonifera chlamydata Cookson & Eisenack 1962, p. 496, Pl. 7, fig. 1-3, 5-8.

Hexagonifera chlamydata Cookson & Eisenack; Cookson & Hughes 1964, p. 61, Pl. 10, fig. 7-9.

Comment. Well-preserved and typical examples of *H. chlamydata* have been recovered

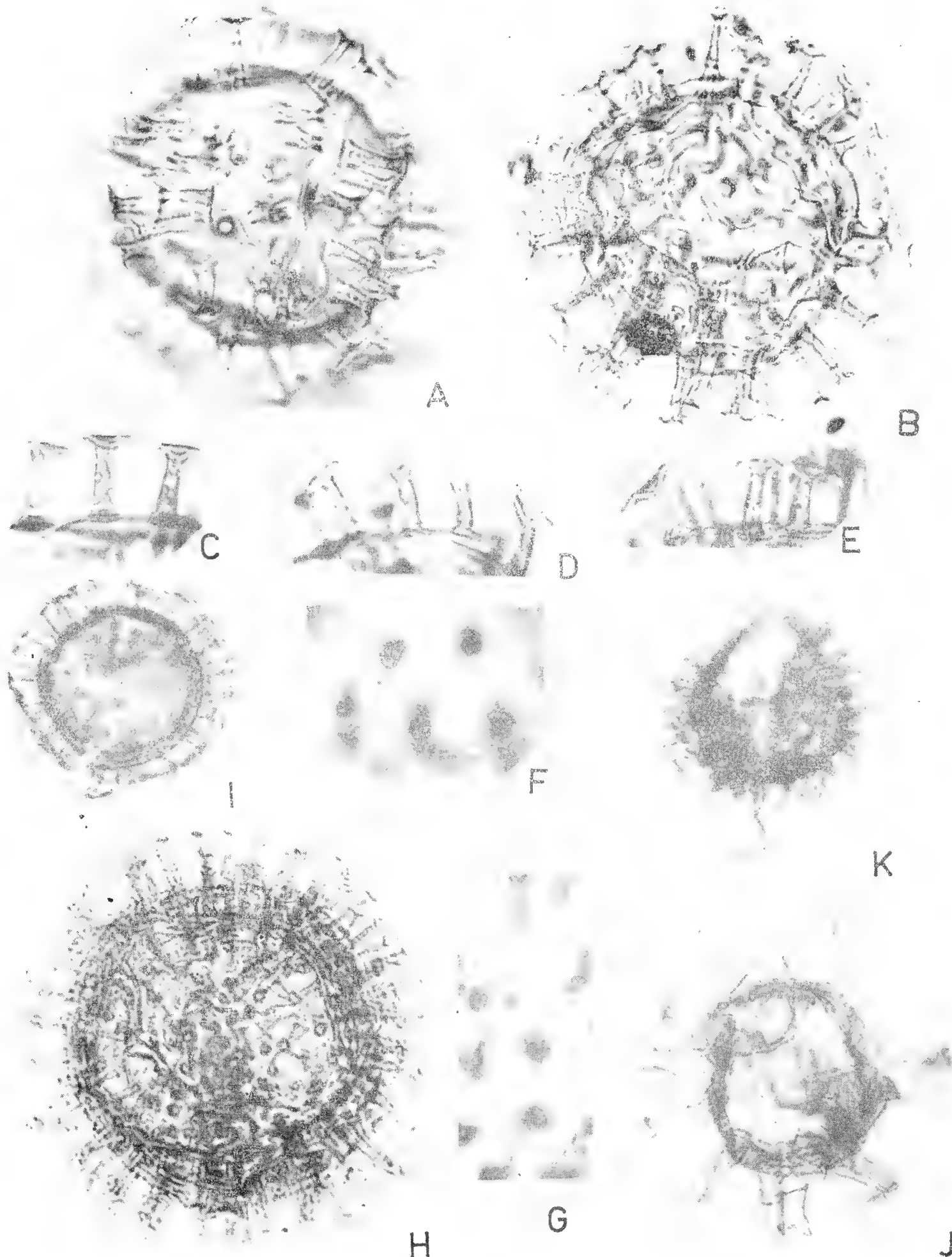


Figure 6. A.—*Cleistosphaeridium ancoriferum* (Cookson & Eisenack) X c. 1,000. B.—*Cleistosphaeridium ancoriferum* holotype X c. 1,000. C, D, E, F.—*Cleistosphaeridium ancoriferum* showing detailed structure of appendages in side view and optical section X c. 1,300. G.—*Cleistosphaeridium ancoriferum*. Portion of the wall showing the V-shaped terminal portion of one appendage and the surface ornamentation of two others viewed from above X c. 1,300. H.—*Chlamydophorella nyei* Cookson & Eisenack, Roma Formation, North Queensland, Paratype showing the dotted membrane which encloses shell and appendages X c. 1,500. I.—*Chlamydophorella nyei* Cookson & Eisenack from Gingin Brook Bore 4, 404-406 feet, X c. 700. J.—*Hystrichosphaeridium stellatum* Maier X c. 500. K.—*Coronifera oceanica* Cookson & Eisenack X c. 500.

from the Gingin Brook core 4 between 404 and 414 feet. All have shown the outer hyaline membrane which envelops the shell.

Genus *Chlamyдохorella* Cookson & Eisenack 1958

Chlamyдохorella nyei Cookson & Eisenack 1958
(Figure 6I, refigured paratype figure 6H)

Chlamyдохorella nyei Cookson & Eisenack 1958, p. 56, Pl. 11, fig. 1-3.
Chlamyдохorella nyei Cookson & Eisenack; Cookson & Eisenack 1962, p. 496, Pl. 7, fig. 14-16.
Chlamyдохorella nyei Cookson & Eisenack; Cookson & Hughes 1964, p. 54, Pl. 1, fig. 12.
Chlamyдохorella nyei Cookson & Eisenack; Manum & Cookson 1964, p. 18, Pl. 5, fig. 3.

Comment. Examples of *C. nyei* have occurred in the Gingin Brook sample from Bore 4 at 404-414 feet. In order to show the detailed structure of this form more clearly than was hitherto possible, a photograph of the Paratype of *C. nyei* taken under oil immersion is given on Figure 6H.

Group ACRITARCHA Evitt 1963

Subgroup POLYGONOMORPHITAE

Genus *Veryhachium* Deunff 1954 emend Downie & Sarjeant 1962

Veryhachium reductum (Deunff)

(Figure 5P)

Veryhachium trisulcum Deunff var. *reductum* Deunff 1959, vol. 2, p. 27, Pl. 1, fig. 8-11.
Veryhachium reductum (Deunff); Jekhowsky 1961, p. 210-212, Pl. 2, figs. 22-37.
Veryhachium reductum (Deunff); Brosius & Bitterli 1961, p. 36, Pl. 1, fig. 3-6.
Veryhachium reductum (Deunff); Cookson & Eisenack 1962, p. 492, Pl. 4, fig. 16.
Veryhachium reductum (Deunff); Cookson & Hughes 1964, p. 56, Pl. 11, fig. 8.

Comment. *Veryhachium reductum* has occurred regularly in preparations of the Gingin Brook sample from Bore 4 between 404 and 414 feet. It was earlier recorded (Cookson & Eisenack 1962) as of common occurrence in the Osborne Formation in the Perth area and Gingin areas and the Carnarvon Basin, Western Australia of ?Albian-Aptian to Cenomanian age. *V. reductum* was noticeably absent from the younger of the two Gingin Brook Bore 4 samples, namely the silty limestone at 202-204 feet considered earlier in this paper.

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12.—Barley Diseases in Western Australia: Their Distribution and Pathogenic Characteristics

by T. N. Khan*, W. J. R. Boyd*
and W. A. Shipton†

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Abstract

A survey of the occurrence and distribution of the diseases of cultivated barley in Western Australia is reported.

The commercial significance of the major diseases is indicated together with information on their geographical distribution, variability of infection and their pathogenic characteristics. Differential hosts for each of these diseases have been identified, together with potential sources of host resistance.

Introduction

Approximately 5 per cent. of the area, annually sown to cereals in Western Australia, is planted to barley. The 400,000 acres involved is well distributed over the wide range of agro-ecological conditions prevailing in the cereal growing areas. Two species are planted; 2-row (*Hordeum distichum*) and 6-row (*Hordeum vulgare*). The former, which occupies 20% of the area, is traditionally utilized for malting purposes. For this reason its production is essentially concentrated in the area contained between the 14" and 20" annual isohyets (Fig. 1). In the wetter areas, in which limited cereal production occurs, and in the drier areas from which inferior malting quality grain is produced, the 6-row cultivars predominate (Fig. 1).

With the reduced significance attributed to the crop in general and the limited breeding activity and agronomic research accorded to it in the past, little summarized information is available on the distribution and pathogenic characteristics of the barley diseases occurring. The purpose of this paper is to provide much of this data, report upon those sources of host resistance that may usefully contribute to breeding programmes, and to indicate those genotypes which may aid in the identification of physiological races.

Barley diseases recorded in Western Australia

Smuts (*Ustilago* spp.) were the first diseases recorded on barley in Western Australia (Chambers, 1960a), and apparently caused some losses prior to the early 1920's (Cass Smith, 1954). Since 1954 there have been indications that loose smut is increasing in importance, particularly in the wetter areas of the State (Chambers, 1960a).

Since the identification of loose and covered smuts, 15 other diseases have been identified (Table 1). Some of these diseases occur throughout the State, and though sometimes occurring in epidemic proportions, have aroused surprisingly little interest (Chambers 1960a, Shipton 1966a).

Powdery mildew appeared to assume some importance in 1955 when it was prevalent in the wetter areas of the State. Again, in 1959 the disease was widespread (Chambers 1960a).

Scald was recorded on barley in 1926 and the first report of net blotch on barley was in 1953. It is likely, however, that net blotch had been present for some time before its identification. Net blotch and scald are economically important overseas (Anon. 1958; Yamada and Shiomi 1954). However, despite their widespread occurrence and their ability to cause considerable defoliation in W.A. (Anon. 1961; Chambers 1960b), they have received little attention. Contrary to earlier opinion (Anon. 1961) it would now appear from the work of Shipton (1966a) that net blotch is causing considerable losses in yield. The position in regard to scald is probably similar.

Stem rust appears to occur readily on barley providing the plants are not too mature at the time when inoculum is abundant in the spring. Previous records show that barley growing in the vicinity of rust outbreaks can be moderately to severely attacked (Chambers 1960a).

Barley yellow dwarf is a disease that has aroused considerable interest since its discovery in 1961 in W.A. Reports indicate that the disease is often serious in the wetter cereal growing areas. However, there appears to be some confusion between the symptoms caused by late infection by this disease and those caused by nutritional disorders. As a result there are few authentic reports.

The above mentioned diseases could be considered of major importance, based on the reports made. Little is known about the other leaf and stem diseases of barley, listed in Table 1, other than the fact that they have been recorded.

Root rots appear to be generally distributed throughout the state (Chambers, personal communications), but are apparently not a serious limiting factor to barley production.

Review of alternative hosts harbouring Recorded barley diseases in Western Australia

Records have accumulated over many years on the alternative hosts of various organisms which attack barley. The data are given in Table 2. They have been extracted from the disease lists of Chambers (1959, 1960a, 1961), McNish (1964, 1967), and the report from Khan and Boyd (1968).

Survey methods and materials

The observations and results reported in this paper have been collected since 1964. The methods used have varied and include field surveys, the growing of the 1962 International Barley Disease Nursery (IBDN) at numerous locations, together with supporting laboratory and glasshouse studies.

The initial observational survey in 1964 was followed by more systematic surveys in 1965, 1966 and 1967. Such surveys were facilitated by the fact that the commercially available cultivars are susceptible to all diseases occurring except leaf stripe (*Helminthosporium gramineum*).

* Department of Agronomy, University of Western Australia, Nedlands, W.A.

† Department of Agriculture, South Perth, W.A. (currently, Canada Department of Agriculture Research Station, Winnipeg, Canada.)

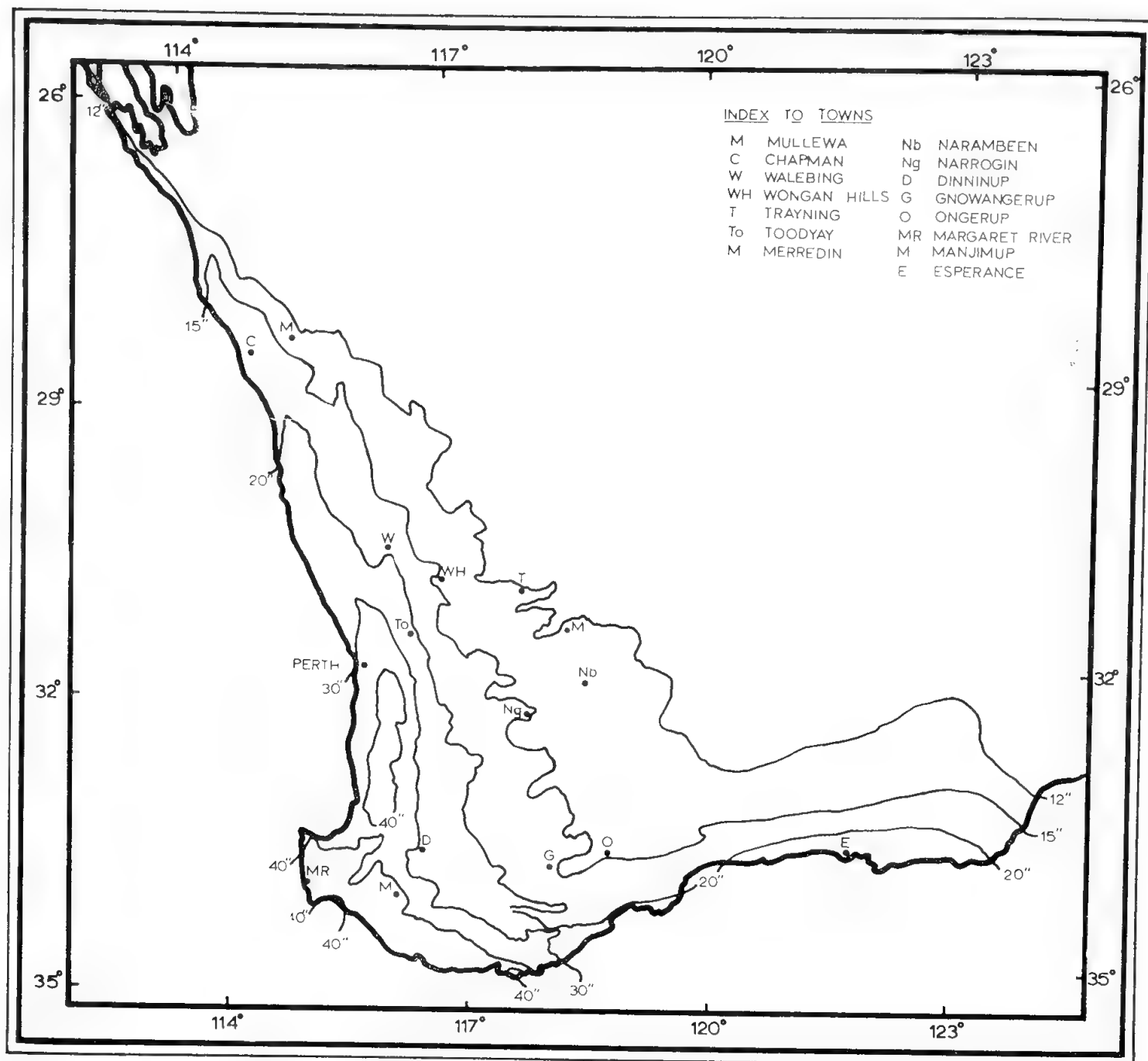


Figure 1.—The southwestern area of Western Australia, selected annual isohyets, and towns referred to in the text.

Table 1
Diseases identified on Barley in Western Australia*

Causal Organism	Disease	Year of First Record
<i>Alternaria</i> sp.	Black Mould	1959
Barley Yellow Dwarf Virus	Barley Yellow Dwarf	1961
<i>Coniothecium</i> sp.	Pink Stain	1927-28
<i>Drechslera teres</i> Drechs.	Net Blotch	1953
<i>Drechslera verticillata</i> (O'Gara) Shoemaker	Leaf Spot	1965
<i>Erysiphe graminis</i> DC.	Powdery Mildew	1924
<i>Fusarium culmorum</i> (W.G. Sm.) Sacc.	<i>Fusarium</i> Root rot	1959
<i>Helminthosporium gramineum</i> Rabh.	Stripe	1924
<i>H. sativum</i> Pamm., King & Bakke	Foot rot	1959
<i>Mycosphaerella tulasnei</i> (Jancz.) Lindau	Black Mould	1924
<i>Ophiobolus graminis</i> Sacc.	Take-all	1927
<i>Puccinia graminis</i> Pers.	Stem Rust	1925
<i>Rhizoctonia solani</i> Kilhn	Foot and Root rot	1959
<i>Rhynchosporium secalis</i> (Oud.) J. J. Davis	Scald	1926
<i>Septoria passerinii</i> Sacc.†	<i>Septoria</i> leaf blotch	1923
<i>Ustilago hordei</i> (Pers.) Lagerh.	Covered Smut	1913
<i>Ustilago nuda</i> (Jens.) Rostr.	Loose Smut	1913

* From reviews of Chambers (1960a), MacNish (1964) and unpublished data.

† Doubtful record.

A list of additional hosts in Western Australia on which organisms causing barley diseases have been previously recorded

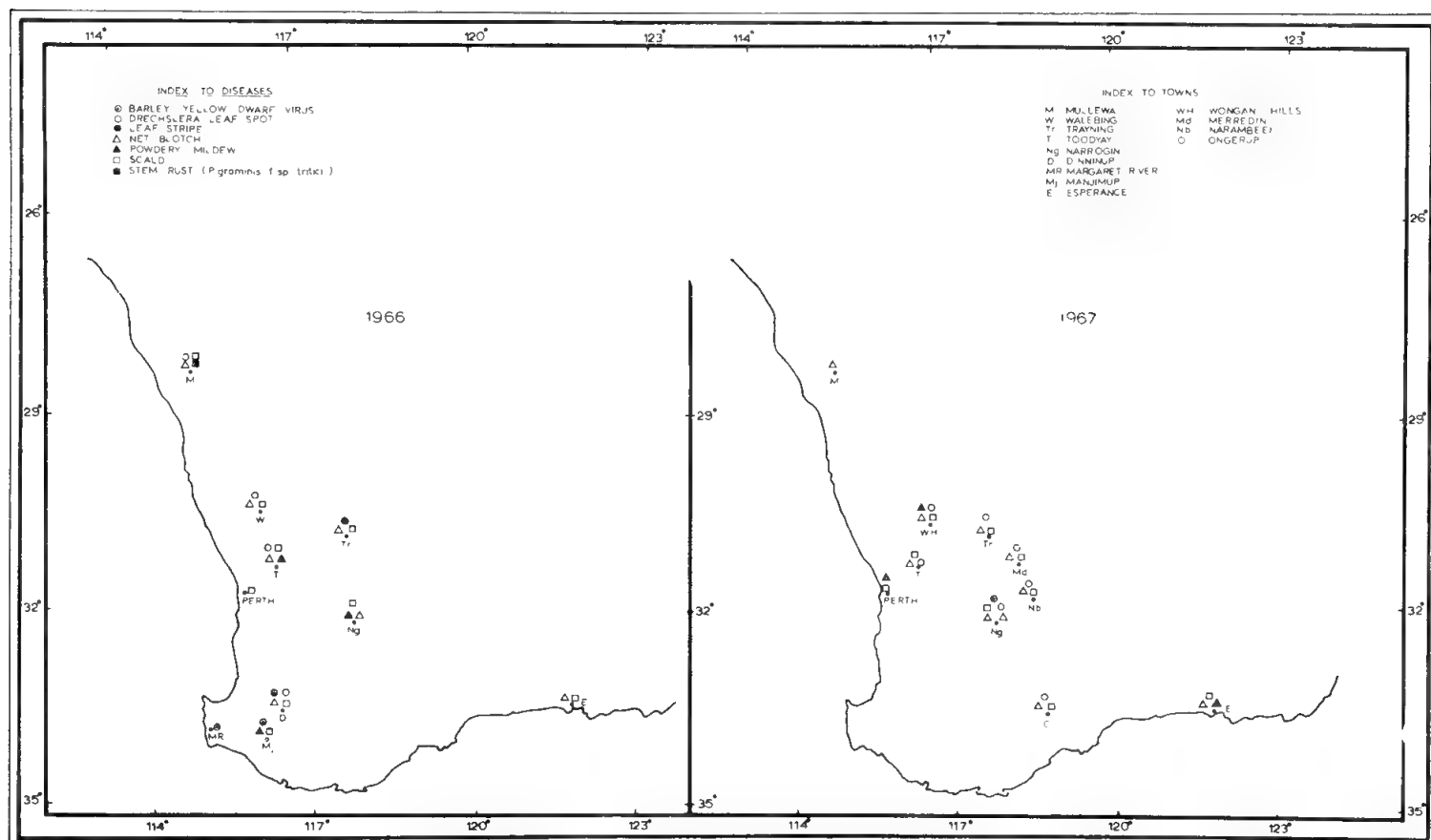
* Doubtful record

The IBD Nursery (provided by Dr. J. Moseman, Crop Research Division, U.S.D.A., Beltsville, Maryland) was first sown at Perth in 1965, at eleven locations in 1966 and ten in 1967 (see Fig. 2). The system of scoring used, followed that outlined in the instructions which accompanied the imported seed. At each location entries were planted in 3' rows spaced 2' apart and replicated twice. The local varieties, Prior and Beecher, were included as additional controls. In the case of these disease nurseries, a disease is considered to be of major significance

In all years of the survey, samples of diseased plants were collected. These were later isolated on a range of media, and identified. Specimens not identified were sent to the Commonwealth Mycological Institute, Kew, for study.

The distribution of the diseases recorded

The diseases encountered, and their distribution, can be classified as follows:



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1. Regularly encountered and of widespread distribution:

Net Blotch (*Drechslera teres*)
Scald (*Rhynchosporium secalis*)
Mildew (*Erysiphe graminis*)
Leaf Spot (*Drechslera verticillata*)

2. Regularly encountered but of restricted distribution:

Rust (*Puccinia graminis* f. *tritici*)
B.Y.D. Virus
Leaf Stripe (*Helminthosporium gramineum*)

3. Irregularly encountered but of wide distribution:

Roots rots (various fungi)
Smuts (*Ustilago* spp.)

Leaf spot (*D. verticillata*) was found throughout the State, but in almost every instance, confined only to the seedling stages. It is hardly likely to be of economic significance except in those instances in which the seedlings are severely attacked and when the disease persists to a later growth stage (e.g. Walebing IBDN in 1966, see Fig. 2).

Powdery Mildew (*Erysiphe graminis*) was observed throughout the State during the period 1964-1967. Principally, however, its occurrence was most regular in the wetter western portion of the areas considered. Its appearance to the east of the 14" annual isohyet would be confined to the lower leaves of densely growing crops, unless favourable climatic conditions favoured its persistence. The disease is considered to be of economic significance only on certain occasions.

Scald (*Rhynchosporium secalis*) was distributed in much the same fashion as mildew. The disease predominates in the areas west of the 14" annual isohyet, and although recorded in the drier parts (e.g. Trayning 1967), the incidence of infection is only slight. (Average number of lesions per plant at Narembeen 1966 was 1.1, at Trayning in 1967 1.4, and at Mullewa in 1966 2.1). In the more endemic areas this disease proved serious and extremely destructive (average per cent. defoliation at Narrogin in 1966 was 71%, at Toodyay in 1967 58%, and, at Perth in 1966 and 1967, 90-95%).

Net Blotch (*Drechslera teres*) provided the antithesis of scald. This disease is endemic and destructive in the drier northern and eastern areas (west of the 14" isohyet), and although regularly observed in the wetter areas its significance is much reduced. Estimates of leaf defoliation at Narembeen and Chapman were 78% and 95% respectively.

Of the diseases considered to be geographically restricted, stem rust (*Puccinia graminis* f. sp. *tritici*) occurred in the IBDN at Mullewa in 1966 and at Esperance in 1967. In each of the survey years it was recorded in areas adjacent to these nurseries. Mullewa and Esperance are traditionally considered the most rust liable districts. This is due to the frequent occurrence of climatic conditions favouring the development and spread of the rust fungus in the period after head emergence. This is earlier at Mullewa (September), than Esperance (October) (Ship-ton 1966). In the event of unseasonably late rains occurring at these times the possibility of

rust attack exists. Such was the case at Merredin in 1964. At Perth rust has been observed from 1965-67 in late season irrigated crops.

Barley yellow dwarf virus was observed in the higher rainfall areas in the S.W. corner of the State. The I.B.D. Nurseries located in this area in 1966 were severely attacked (Margaret River) or seriously infected (Manjimup and Dinninup). One of us (W.S.) has observed this disease at Beverley but symptom expression is only poorly developed.

Helminthosporium gramineum, the casual agent of leaf stripe, failed to reveal itself on any of the commercial varieties grown or upon the controls in the IBDN. Its presence, however, can be determined from its attack on the variety San Carlos (C.I. 11533), and this has occurred only at Trayning in 1966 and 1967 and at Narembeen in 1967. In 1965 it was recorded, at Perth, on the variety Odessa (C.I. 934).

The remaining diseases, root rots and smuts (*Ustilago* spp.) have been recorded on a very few occasions and from widely separated areas.

The severity of disease incidence, and its variability

The most noteworthy aspect of the surveys conducted relates to the above variability. Net Blotch, which proved endemic and serious in the drier areas, (corresponding to an area east of a line linking Mullewa, Trayning, Gnowangerup and Esperance) showed little incidence in the 1966 Trayning and Esperance nurseries. In surrounding areas, however, very severely affected crops could be observed. Similar variability was experienced with Scald. This disease which proved endemic and serious in the higher rainfall areas (resulting in complete defoliation in some instances e.g. Narrogin, Toodyay and Perth in 1966), was only of limited significance at Narrogin in 1967 and in surrounding areas.

Variability from field to field was observed, and this could, for the most part, be associated with any of the following 4 situations:

- (i) Early sown crops (inevitably leading to (ii) below)
- (ii) Well developed crops of high yield potential
- (iii) When barley followed barley
- (iv) Use of seed from a crop previously infected. (Tests conducted on grain receivals at Esperance recorded a 35% infection of Net Blotch.)

Despite the geographic generalization made above, isolated crops severely affected with Net Blotch were observed west of Toodyay and south-west of Dinninup in 1966. Both had been early seeded. Similarly, severe but isolated infections of Scald were noted north of Gnowangerup and east of Narrogin.

Diseases newly identified

A number of cultures obtained from cultivated barley in the course of these studies were forwarded to the Commonwealth Mycological Institute for identification. They were as follows:

CMI 128829 *Cladosporium herbarum* (Pers.)
Link ex Fr.

- 128830 *Pyrenophora semeniperda*
(Brittleneck + Adam)
Shoemaker.
128832 *Colletotrichum graminicola*
(Ces.) Wilson
128834 *Mocrophoma* sp.
128835 *Alternaria* stage of *Pleospora*
infectoria Frickel.

Identification of previously unreported wild hosts

The following hosts for the fungus *D. verticillata* were found:

- Briza maxima* L., *B. minor*, *Bromus gussonii*, *B. rubens* L. *Phalaris minor* Retz., *Polypogon monspeliensis* (L) Des. f.

Pathogenic variability encountered

Studies of "Field" pathogenic variability were limited to those nurseries in which the disease in question was present in epidemic proportions, and where the control varieties in each replicate were severely attacked. The results obtained are summarized below (see Table 3).

It may be noted that, for four diseases, evidence of pathogenic variability was obtained. For each, suitable differential cultivars were identified. In Table 4 cultivars resistant at all locations to one or more of the diseases studied is presented. It may be noted that 2 cultivars are recorded as resistant to BYD virus. No complete resistance was recorded however. At the Margaret River location all cultivars were affected. The two indicated as resistant revealed some degree of tolerance. This tolerance was more marked at Manjimup and Dinninup. A number of cultivars were recorded as resistant to *D. verticillata*.

Conclusions

As a result of the above reported surveys and studies, a number of conclusions may be drawn. Seven major barley diseases occur in W.A. They include net blotch (*Drechslera teres*) which is widely distributed, endemic in the shorter growing season areas in the north, and serious in the lower rainfall areas. Two field races were identified. Scald (*Rhynchosporium secalis*) proved widely distributed, and its economic significance increased to near epidemic proportions in the higher rainfall areas. Three field races were identified. Both diseases exhibited considerable variability in the severity of their attacks. This variability could be associated with earlier dates of seeding and crops of high yield potential. As these aspects are themselves related, it is presumed that a suitable microclimate is developed, facilitating infection and disease development. As grain yield reductions of up to approximately 20% (Shipton 1966a) have been reported from moderately severely affected crops, these diseases must be considered a serious limitation to improved barley productivity. Sources of resistance to both have been located. (See Table 4). The need for improved crop sanitation procedures is indicated due to the seed-borne nature of these diseases and their greater incidence in crops following previous barley.

Two widely distributed, but apparently less significant, diseases to be encountered were powdery mildew (*Erysiphe graminis*) and leaf

Table 3

Indicating the number of field races identified for each of the following diseases, and suitable differential varieties for their identification (UR = Universal Resistant; US = Universal Susceptible)

Disease	Number of field races identified	Differentials
Net Blotch (<i>Drechslera teres</i>)	2	Marocaine 079 (CI8334), Nepal (CI595) UR = Abyssinia (CI9588) US = Prior
Scald (<i>Rhynchosporium secalis</i>)	3	Hispoint (CI8828), Trebi (CI936), (CI1234) UR = Marocaine 079 (CI8334) US = Prior
Powdery Mildew (<i>Erysiphe graminis</i>)	2	Gopal (CI1091) Valentine (CI7242), Goldfoil (CI 928)* UR = Hispoint (CI8828) US = Prior
Stem Rust (<i>Puccinia graminis</i>)	2	Feeber (CI7260) Valentine (CI7242) UR = Husky (CI9537) US = Prior

* Goldfoil is a differential for races 3 and 18 of *E. graminis* (Luig et al 1958).

spot (*D. verticillata*). Both diseases were more prevalent in the wetter regions of the State, and both were particularly prevalent during the seedling stages of growth. Considerable variability of seedling incidence was observed, but no plausible reason could be developed. Two field races of powdery mildew were encountered and sources of resistance to both diseases were identified.

The remaining three diseases considered to present a serious potential problem were rust (*P. graminis* f. spp. tritici), BYD virus and *Helminthosporium gramineum*. Each revealed distinct geographic isolation. Two field races of rust were encountered and sources of resistance or tolerance (to BYD virus) were observed.

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Table 4

Varieties resistant to specific diseases at all W.A. Locations tested (*). Varieties reported as resistant to these diseases in other countries are noted (+). This information has been obtained from details supplied with the 1962 I.B.D.N. and Moseman (1964)

Varieties resistant at all locations to :

Variety	CI No.	Origin	BYDV ‡	Drechslera leaf spot	Net Blotch	Powdery Mildew	Scald	Stem rust
Algerian	1179	Algeria			*	*†		
Anoidium	7269	Argentina	*†					
Anoidium x BC 2562 (Rabat) 04805-9-5-20	11538	Canada				*†		
Anoidium x BC 2562 (Rabat) 04805-10-13-1-1	11539	Canada				*†		
Belli Barley	6182	Hybrid		*				
Black Russian	2202	Tiflia			*			
Br. Sel. 3962-4	11542	Canada			*			
Br. 5180-30		Canada		*				
Br. 5746-2g M.R. JV		Canada			*			
Cebada Cape	6193	North Africa			‡			
Comfort	4578	Hybrid			*			
Decortiatum	2230	Hybrid					*	
Div. 6472-58-12313		Argentina					*	
Dorsett	4821	Manchuria				*†		
Engledow India	7555	Argentina				*†		
Goldfoil	928	Pl. Sel.			*			*†
Hispoint	8828	Germany			*	*†		*†
Husky	9537	Canada			*			*†
J 20		Japan				*†		
Kinai No. 5		Japan		*	*			
Long Glumes	6168	Hybrid				*†		
Manchuria	2330	China			*			
Marocaine 079	8334	France				*†		
Mainwali	3400	India				*†		
Modia	2483	North Africa				*		
Monte-Cristo	1017	India				*		
Moore	7251	Wisconsin						*†
Multan	3401	India				*		
O.A.C. 21	1470	Canada			*†			
Oderbrucker	940	Pl. Sel.			*			
Psaknon	6305	Australia						
Quinn	1024	Australia					*†	
Rabat	4979	Morocco				*		
Russ. No. 68		Japan		*				
Russ. No. 74		Australia					*	
Speciale	7536	Hybrid			*			
Spiti		Argentina				*		
Stephan	8051	Germany			*	*†		
Sudan	6489	Portugal			*	*†		
Tregal	6359	Hybrid		*				
Weihenstephen		Japan		*				
	1243	Abyssinia			*†			
	2376	Abyssinia					*	
	2549	Italy			*			
	3208	Abyssinia					*†	
	-1							
	3906							
	1	Abyssinia					*†	
	3926	Abyssinia			*		*	
	3							
	4220							
	1	Abyssinia			*			
	4226	China			*†			
	4487	Manchuria			*			
	4493	Manchuria			*			
	4578	Hybrid			*			
	4795	Manchuria			*†			
	4929	Manchuria			*†			
	4935	Manchuria			*			
	5644	Atrada Kuban					*†	
	7117							
	77				*	*†		*†
	7251	Wisconsin						*†
	7619	India		*		*†		
	7728	India				*†		
	8111	Pl. Sel.			*	*†		
	8158	Turkey			*		*†	
	8159	Argentina					*	
	8251	Turkey				*	*	
	9588	Abyssinia	*†	*	*			

‡ Varieties tolerant to BYDV

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